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Electric Locomotives on Mountain Grades.

Engineers are so accustomed to the high cost of operation, the dangers, the delays and limitations inherent in the operation of mountain divisions of railroads with steam locomotives, that these things have come to be looked upon as essentially inseparable from mountain railroading. Until the trial of the Mallet compound locomotive, with its tremendous weight on drivers and correspondingly increased drawbar pull, it had been necessary to break up long

trains at heavy grades and operate each of the sections with two or more steam locomotives of the largest capacity. The Mallet compound has done much to improve conditions where a large drawbar pull and great horse-power capacity are required, but the results thus far obtained in its operation still leave much to be desired, especially in view of the improvements in operating methods which seem to be possible with the adoption of the electric locomotive.

Electric operation on mountain grades appears to offer many advantages of greater importance than a generally admitted small saving in the expense of fuel, though this in itself may prove a most attractive feature under certain conditions and in certain localities. Admitting that electric power produced in hydro-electric stations costs less per ton-mile hauled than coal inefficiently burned under the abnormal overload conditions obtaining in steam locomotive operation on mountain grades, this item in itself will seldom show a sufficient return on the capital required for electrification to make it attractive to the steam railroad management.

It is a well known fact that the figures given in annual reports for locomotive maintenance running from six to ten cents per locomotive-mile do not apply to those locomotives operating under heavy grade conditions, and a maintenance charge ranging from ten to eighteen cents per locomotive-mile is not uncommon in this class of work. It is contended that the electric locomotive can perform the same service with a much less maintenance charge than is required in steam locomotive operation; while the 50,000-mile endurance run of the New York Central locomotive extended but a year, it showed a maintenance charge of less than one and one-half cents per locomotive-mile, and it is probable, according to electrical specialists, that an electric locomotive properly proportioned for service can be maintained for much less than a steam locomotive performing the same service. Just what the gain will be in this direction is not apparent from operating figures, and it will be interesting to see results from the New York Central electric zone after electric locomotives have been in service operation for a year or more. The saving in the maintenance charge of locomotives is reflected more generally than merely in labor and material for necessary repairs, as a low maintenance account means great reliability, and freedom from breakdowns and delays, so that if all expenses due to failure of locomotives in service were charged directly to maintenance of locomotives this item would assume formidable proportions. Hence, a saving in this item is of far-reaching importance and should prove a valuable asset to the electric locomotive on heavy-grade work, where the conditions of operation are very exacting as regards performance of the motive power.

The great advantages offered by the introduction of the electric locomotive seem to lie more in the direction of increasing the tonnage capacity of the single track, commonly met with on heavy grade divisions, and the general reduction in cost per ton-mile resulting from the handling of heavier trains at higher speeds with a certainty of operation not shared to an equal extent by the steam locomotive. Where the capacity of the electric motor is properly proportioned to the work which it has to do, there is no doubt of its being a highly efficient and extremely reliable piece of apparatus, requiring little or no attention, only periodic inspection, and with complete independence of the round houses, coaling towers, water tanks, and ash pits, required for the frequent repairs and grooming of the steam locomotive. This freedom of action and reliability must be reflected in a greatly

increased daily mileage, a lower crew expense, and a considerable curtailment of the false mileage common to steam locomotive operation.

The electric locomotive is merely a transforming or converting piece of apparatus and can draw an unlimited supply from its distant stationary power house; hence its output is limited only by mechanical considerations, and the result is a type of locomotive capable of delivering an enormous power if designed to do so. Its motive power can be sub-divided into several motor units without loss in efficiency or increase in dead weight, thus permitting a construction which can utilize the entire weight of the locomotive upon the drivers and still keep within the recognized limits of weight upon each driving axle. Not only can the motive power in one locomotive structure be divided to suit the convenience of construction, but two or more locomotives can be coupled together and operated by a single motorman in the cab of the leading locomotive. While the steam locomotive, and especially the larger types as represented by the Mallet compound, is seriously handicapped by the difficulty and expense of stoking, the electric locomotive can be operated in groups of two or more by a single operator who has under his complete control the 2,000 or 3,000 h.p. concentrated in each of the several locomotives of the group. The possibilities opened up in this direction are enormous.

A steam locomotive is considered large when its boiler is capable of sustaining an output of from 1,500 to 2,000 i. h.p. The electric locomotive, on the other hand, as represented by the 3,400 type now operating on the New York Central, can give a sustained output of 2,200 h.p. rated with ample margin of overload in excess of this. It should be well understood also, that this 2,200 h.p. output of the motors is obtained with a total weight of something less than 100 tons, of which 68 tons is upon the drivers, and this locomotive was designed for a specified duty and does not in any way represent the maximum possibilities of electric locomotive construction.

It seems entirely practicable to construct an electric locomotive or a group of electric locomotives capable of delivering any drawbar pull permitted by the strength of the drawheads, and, moreover, this drawbar pull can be delivered at any speed desired, in this respect far exceeding the possibilities of steam locomotive construction. This means that instead of operating trains downgrade at a maximum speed of from 25 to 30 miles an hour and up grade at a maximum speed of from 6 to 12 miles per hour, it is possible with electric locomotives to operate at any speed up grade that is consistent with the alignment of the track. In other words, the same schedule speed can be maintained up grade and down grade, thus greatly facilitating the movement of trains on heavy grade sections and vastly increasing the tonnage of the tracks.

Air brake equipments on all cars have contributed towards increasing the size of trains and safety in operation on mountain grade sections, but such operation is still handicapped by the limitations and dangers attending the holding of a heavy train on a downgrade of long extent. As the electric locomotive is a convertible piece of apparatus, changing electricity into mechanical power and vice versa with equal efficiency, it offers a means of relieving the air brake entirely or in part, and performing the functions of braking by returning electricity to the line. Elimination of air-brake shoe troubles and overheated tires, will be appreciated by steam railroad operators as soon as this valuable feature of the electric locomotive becomes well understood, and aside from the economic value of electric braking, it offers much towards the safety of carrying passenger trains over mountain grade sections.

This is peculiarly an age of engineering struggle and the battle between high-power guns and armor plate is equally reflected in railroading between the constructors of locomotives and the builders of roadbeds. The electrical engineers seem to have available a type of locomotive which can use existing roadbeds without subjecting them to additional burdens, at the same time ensuring material economies over steam locomotive operation. The initial step towards electrifying mountain divisions has already been taken by the Great Northern Ry. in equipping its Cascade Tunnel, and larger projects are under careful consideration by other roads, and will probably result in more electrified heavy-grade sections in the near future.

The Cambridge Bridge Over the Charles River.

The recent dedication of the Cambridge Bridge between Cambridge St., Boston, and Main St., Cambridge, which has been under construction for several years, is an event highly gratifying to those who believe that bridge work in this country is capable of a much higher artistic development than is generally permitted by those paying for the structures. The Cambridge Bridge has been in charge of a commission consisting of Dr. E. D. Leavitt and the mayors of the two cities it connects. To the public spirit of Dr. Leavitt is largely due the success of the commission's work, for through his influence it was determined at the outset that this bridge should not be a mere utilitarian structure, spanning the river between these two cities with a minimum expense for steel and masonry, but should be a structure worthy of the importance of the site and an ornament to the great parkways which have already been partly developed along the banks of the Charles River, and eventually will extend along both banks for a distance of over twenty miles, forming a water park of the first rank. The technical features of the work were assigned to Mr. Wm. Jackson, city engineer of Boston, and Mr. E. M. Wheelwright, the well-known Boston architect. The assistant engineer was the late John E. Cheney, who took a deep interest in it and left the imprint of his skill as a designer in all the structural details, some of which have already been illustrated in this journal.

Before any plans were prepared, Messrs. Jackson and Wheelwright visited Europe to become thoroughly familiar with the bridges in the important cities across the Atlantic. It may be recalled that The Engineering Record printed some years ago a series of large engravings from some fifty of the most interesting of the photographs these gentlemen gathered during their tour of inspection. It might be stated that before making this journey, Mr. Jackson had no preconceived ideas regarding the type of structure to be employed, although he was naturally enough glad to have an opportunity to design a bridge in which the question of dollars was relegated to a minor position as compared with artistic merit and harmony with surroundings. Mr. Wheelwright, on the other hand, visited Europe with the expectation of learning that stone arches were the only true solution of such a problem as that presented in this structure. After critically examining the important bridges of the Continent, it was apparent, however, that it was practicable to build steel structures possessing all elements of structural beauty, and that masonry not only had been forced from its old position as the leading material for artistic bridge-work, but had even been compelled to give way to steel for structures of the highest aesthetic rank under certain conditions. This fact was particularly evident from a study of the bridges in Dresden,

illustrations of which were among those included in the series already referred to.

While the first suggestions for the bridge were being developed, the commission found it necessary to secure permission to build a structure without a draw span. At first it was believed that such a draw could be introduced without spoiling the effect of the structure as a whole, and it was proposed to make the central feature an artificial island with a channel cut through it at the draw. It was found impossible, however, to design a bridge having a draw span which would be satisfactory artistically and, accordingly the Massachusetts legislature was petitioned to authorize the construction of a bridge without a draw, crossing the channel at a height sufficient to furnish a clear headroom of 26 ft. above mean high water at the central spans. This gives a sufficient height to allow tugs and vessels without masts to pass, and as there is no business to speak of above the bridge it was felt that the injury which might arise to a few riparian owners through the closing of the river navigation to larger vessels was more than counterbalanced by the gain in the character of the bridge. Unfortunately the War Department refused to agree to this opinion, and it was necessary to secure the passage of a bill in Congress and its approval by President McKinley in order to permit the construction of a drawless bridge. Two years were occupied in these legislative proceedings, but it was absolutely essential to carry them through in order to enable the engineer and architect to reach the best possible result, which alone would be acceptable in the case of the Cambridge Bridge.

Before the final design was adopted, about fifty carefully worked out studies had been made. Each of these was prepared to show the effect of some change in spans, piers, grades or points of structural emphasis, and every suggestion having any merit, structurally or artistically, was thoroughly discussed before decision was reached concerning it. It was learned early in this investigation that the best effect would be obtained by laying emphasis on the central portion of the bridge, increasing gradually the length of the arches from the shore to the center of the bridge and making the piers successively heavier as the central channel was reached. The length of the bridge between abutments is $1,767\frac{1}{2}$ ft., and it has eleven spans, each of twelve steel ribs, varying from $101\frac{1}{2}$ to $188\frac{1}{2}$ ft. The height of the bridge at the center is about $48\frac{1}{2}$ ft. above low water. The main effect of the structure is produced by the use of two large central piers, each having a foundation 201 ft. long by 67 ft. wide; these piers have ornamental stone towers rising to a height of 40 ft. above the roadway, and smaller stone towers have been built at the end of each abutment. In designing the masonry of these piers the purpose was to obtain the happiest possible expression of monumental dignity and not to keep the number of cubic yards down to the minimum consistent with strength. As a result, these great piers completely overshadow the masonry structures used on other bridges across the Charles River and demonstrate in a most striking manner the possibilities of stone masonry combined with structural steel for the expression of graceful strength. They also call attention to the fact that the bridge crosses the boundary line of two important cities.

Attention is particularly called to this structure because it is one that should be visited by all engineers and architects who have an opportunity to inspect the structure. It is the result of the most careful and painstaking attempt yet carried through to completion in this country to build a bridge which is artistically as well as structurally in perfect harmony with

its position and with its purpose. Dr. Leavitt and Messrs. Jackson and Wheelwright are to be congratulated on the success of their work, which stands forth as one of the few really satisfactory American bridges from every point of view.

Large Reinforced Concrete Syphons.

The beginning of the construction of the Catskill Aqueduct for the additional water supply of the City of New York obviously brings into prominence many serious questions of design of the main features of the work. Among these important problems of design there is probably none requiring more serious consideration than that bearing upon the proper construction of syphons under the deep valleys crossed by the aqueduct line. The most evident forms of construction, those which most easily suggest themselves, are deep tunnels and riveted steel pipes. The deep tunnels are naturally carried to such depths as to pierce bedrock under the lowest points of the geologic valley crossed. This frequently necessitates the construction of shafts several hundred feet deep with the base of the tunnel carried still deeper. These pressure tunnels can usually be lined with comparative economy so as to make them actually or practically water-tight, and they serve their purpose admirably as structures if an excessive amount of water be not encountered in their construction. They need, however, provision for being pumped out at proper intervals for examination, cleaning and repairs, if necessary, all of which at such great depths involves inconvenience and expense.

The riveted steel pipe, on the other hand, aside from questions of relative cost, lies near the surface of the ground and is depressed to no greater depth than is necessary for suitable covering and protection. It is therefore subjected to a relatively low pressure no greater than the minimum required by the topographic features of the valley. This is a great advantage and reduces some important parts of care and maintenance, but it is offset by the perishable character of the metal, which can scarcely be completely protected against all corrosion. It is clear that the riveted steel pipe would be more suitable for a short syphon than a long one where the cost of shafts would be distributed over a comparatively long high pressure tunnel.

The obvious advantages of surface construction, or in some places of a type of aqueduct suitable to be carried across a valley on a masonry or other bridge structure, and, furthermore, of a more permanent character than that of a steel pipe gives much interest to the recent construction of a reinforced concrete syphon forming part of an irrigation canal in Spain, as described in "Le Genie Civil." This syphon has a length of about 3,200 ft., and consists of two tubes each 12.5 ft. in diameter. It may be contended, strictly speaking, that these tubes are mortar-lined and concrete coated steel pipe rather than reinforced concrete, and the contention would at least be reasonable, for each tube consists of a riveted steel pipe $\frac{3}{8}$ inch thick reinforced on its exterior with steel ties. These steel pipes are coated with six inches of concrete on their exterior which encloses and imbeds the reinforcing ties. The interior of the pipe is lined with seven-eighths inch of mortar. The steel pipe is continuous throughout the length of the syphon, being fitted with expansion joints and thus affording a continuous water stop.

This is an interesting structure, especially in view of the large diameter of the tubes, at the same time it does not afford opportunity for learning much about what reinforced concrete would do in such a structure. A continuous steel

pipe of such a diameter lined with a thin interior layer of mortar and covered with but six inches of concrete is practically a series of comparatively thin cylindrical laminations. While water tightness is secured, it is at the cost of unity of the materials composing the syphon. It will be exceedingly difficult if not impossible to prevent the thin interior layers of mortar from cracking sufficiently to permit the water to come into contact with the steel, resulting in serious corrosion. In such a structure there is complete failure to secure that intimate and inter-structural combination which constitutes one of the most excellent features of reinforced concrete and without which failure of detail is invited.

The obvious reason for not using reinforced concrete for syphon tubes, aside from any matters of cost, is the lack of water-tightness of ordinary concrete. There has been, however, much advance made in securing this quality, so necessary for the purpose under consideration. Concrete sufficiently water-tight for aqueduct purposes, up to heads of sixty feet or more, has already been made, and experimental investigations indicate that it may be feasible to reach far greater heads. The maximum head on the Spanish syphon is eighty-five feet and there should be no serious difficulty in constructing a true reinforced concrete tube to meet the requirements of such conditions, nor would it be difficult to provide effectively against expansion and contraction with longitudinal steel.

Recent investigations have resulted encouragingly for the early attainment of concrete practically impermeable to water up to heads far beyond any hitherto considered. The intimate combination of the concrete and steel enables a sufficient mass to be used to eliminate any prejudicial effects of fine cracks. A properly designed and constructed reinforced concrete syphon would be as permanently enduring as any other first class masonry, and with all the advantages of complete accessibility, convenience and low cost of care and maintenance.

The Value of Small Drawings.

So much has been said about the value of small drawings in construction work that the subject would not be referred to at this time if evidence was not constantly proving the laxity of many companies in keeping their drawing office practice up-to-date, and their failure to realize that in probably half of all cases drawings for field use not larger than 11x14 in. are better than anything bigger. It should be needless to go over all the arguments against the custom of making single drawings for construction work big enough to convert into a suit of clothes. Sometimes, of course, a map must be drawn on so small a scale that the territory cannot be shown on less than 6 to 10 sq. ft. of paper, but if employers stopped to figure the cost of making large drawings and large prints, let alone the difficulty of filing them compactly, it is safe to say that fewer of those productions would be bulking big in the expensive office spaces of large cities.

An album of small drawings, multiplied as to details, is infinitely more convenient than several huge rolls in which details and general relations are all jumbled together. It can be kept up-to-date much easier, and at less expense. The cost of blue prints is not a negligible quantity under city conditions. Proper rotation and numbering, with suitable cross-references in the drawing index, are all that are needed to maintain the usefulness of the small data sheet. The picture plans required by non-technical clients and boards of directors can just as well be made on an 8 by 10 or 11x14 in. sheet in the majority of cases.

Obviously it costs money to keep drawings up-

to-date, but it costs more in the long run to fail to do this. A prominent firm of engineers recently undertook the re-modelling of a power plant, and the expense for the new foundations was greatly increased on account of the fact that absolutely no record or definite knowledge existed as to the character of the foundation and soil under the plant. The knowledge was obtained finally, of course, by test borings and a long series of tabulations of data, but the expense to the client company was far beyond the cost of maintaining the necessary simple plans in the first place. It is poor policy for a company to be in such a hurry to start its plant that no time can be found to keep the proper records of the character of the construction, and the changes put in effect beyond the original design. From a hasty point of view the money expended on drawings and data in very large engineering undertakings by Federal, State or railroad authorities seems at times needlessly great, but a great system rarely gets through its first operating year without being benefitted in money saved far above the cost of the drawings and data, if the latter have only been kept up-to-date. Particularly in electrical work is there a field for the use of schematic diagrams in which on small sheets stripped of all superfluities, three phase circuits, for example, are shown by single lines, and apparatus by simple symbols. The value of drawings to an operating man is in direct proportion to their straightforward freedom from all draughting complications.

Notes and Comments.

THE RAIN-WATER RUN-OFF from populous districts is one of the most important subjects that the designers of sewerage systems have to consider. In spite of the attention that has been paid to it, surprisingly few absolutely definite data are available and for this reason the sanitary section of the Boston Society of Civil Engineers has appointed a committee to consider the whole subject. The committee is particularly desirous of collecting all records regarding it and engineers throughout the country who have information on the subject are requested to send it to Mr. Harrison P. Eddy, 14 Beacon St., Boston, who is the secretary of the committee. At the present time nothing is so necessary as the compilation and study of available data, and for this reason engineers will do well to assist the committee with whatever information they may possess, since the committee's work is done for the benefit of the whole profession.

A GAS ENGINE TEST lasting two weeks was recently run at the works of the J. P. Eustis Mfg. Co., of Boston, by Messrs. P. R. Nichols and R. F. Knight, of the Massachusetts Institute of Technology. The test was made on a 55-h.p. engine direct-connected to a 30-kw. direct-current generator. The engine was of the vertical, twin cylinder, four-cycle type, the governing being effected by varying the richness of the explosive mixture. Cooling water was circulated by a motor-driven centrifugal pump and the engine was started by compressed air stored in two tanks which were kept filled by an air pump driven by a small motor. The gas used by the engine was taken from the street mains and averaged about 596 B. t. u. per cubic foot. During the two weeks' run, the total kilowatt-hours were 3,146, and the total gas used 92,900 cu. ft.; 31.9 kw. hr. were used in driving the pump, leaving 3,114 kw.-hr. as the net energy delivered during the run. At 70 cents per 1,000 cu. ft., the gas cost 2.09 cents per kw.-hr., the oil cost 0.029 cent, the labor at 2 hr. per day cost 0.193 cent, and the interest and deprecia-

tion, reckoned at 15 per cent. on \$3,000, amounted to 0.555 cent, making the total cost of energy 2.87 cents per kilowatt-hour.

THE REFUSE DESTROYER and electric station described in The Engineering Record of Nov. 11, 1905, which was built by the City of New York to utilize the refuse of a portion of the Borough of Manhattan, has proved an unprofitable venture, so far as the generation of electricity is concerned. The current has been used for public bridge lighting, costing the Department of Water Supply, Gas and Electricity about \$50,000 a year, while the local lighting company would do the same work for about half this sum. The trouble with the lighting end of the undertaking seems to have been that city refuse is a very uneven fuel, and the operation of the plant as an electric generating station is much more difficult than will be its operation as a refuse destructor simply. It is not unlikely that small amounts of current for various purposes will be furnished from it to the immediate vicinity, but it is not believed that any extensive system of public lighting can be safely undertaken.

FOUNDATION TROUBLES at the Mt. Royal pumping station of the Baltimore water works are now being investigated and seem to be due to an unusual condition. One corner of the building has been underpinned and the pier which supported it has been laid bare by sinking a pit some 30 ft. deep. The concrete was found to be in a bad condition and the rock on which the pier rested was also somewhat decomposed. The earth in the vicinity was very warm and moist, and an examination showed that the concrete hot well had been leaking considerably. In addition to the presence of this hot water in the cinder fill which formed the site of this part of the building, return currents from the belt line tunnel of the Baltimore & Ohio R. R. were detected. It is understood that the condition of the concrete is not unlike that described by Mr. A. A. Knudson, in a paper read last winter before the American Institution of Electrical Engineers, concerning the electrolysis of steel embedded in concrete. The conditions at Baltimore are so unusual that when the examination is completed it is to be hoped that all the facts will be made public.

A TRADE CATALOGUE LIBRARY has been established by the Technology Department of the Carnegie Library at Pittsburg, and an attempt is being made there to collect business pamphlets covering the entire engineering field. These publications will be given a prominent place on the shelves, carefully catalogued under both firm name and subject, and made accessible to the public. A similar collection made at a Brooklyn library some time ago proved not only of value to the people using the library but also of service to the publishers of the catalogues. It goes without saying that a practically complete collection of trade publications in a library in a manufacturing city like Pittsburg has a reference value exceptionally high, and for this reason it is believed that manufacturers of supplies for engineers, architects and contractors will find it decidedly to their advantage to send their publications to Mr. H. W. Craver, who is in charge of the Technology Department of the Library at Pittsburg. The formation of such a collection in the public library of each manufacturing city is something that may very properly be investigated by its librarian. The time has gone by when the trade publication is merely a collection of claims for some product, stated without much regard for truth and published without regard to typographical appearance.

THE CONTRACTOR'S PLANT AND METHODS ON THE HARBOR WORK AT GARY, IND.

The construction of a harbor for the new plant of the United States Steel Corporation at Gary, Ind., is one of the most difficult and extensive of the engineering works required in building that plant. The site of the latter is at the extreme south end of Lake Michigan, 12 miles from the South Chicago plant of the steel corporation, and 26 miles from the central business district of Chicago, where an area of about one square mile, with a frontage of over a mile along the shore of the lake, has been provided. This area is covered with fine lake sand to a depth of from 40 to 60 ft. from the surface, which before construction started was formed by a series of alternate ridges and hollows parallel with the shore line. The ridges rose 15 to 40 ft. above the water in the lake, while the general elevation of the depression between them was about 10 ft. above that level. The Grand Calumet River, a sluggish stream that heads in swamps to the east of the site, extends along the rear side of the latter, parallel to the lake, into which it empties at South Chicago, 12 miles away. From South Chicago entirely around the lower end of the lake the shore line is a low, flat and practically unbroken sandy beach. This characteristic shore line existed at the site of the new plant, where the established minimum of 22 ft. in channel construction on the Great Lakes is not reached in the lake until about 2,000 ft. off shore.

General Arrangement of Harbor.—The provision of proper and sufficient harbor and docking facilities for the great number of the largest boats on the Great Lakes which will ply between the new plant and the terminals of the iron-mine railroads on Lake Superior, was rendered a project of unusual magnitude by these natural conditions. A slip, 250 ft. wide, approximately a mile in length and with a minimum depth of 22 ft. of water, is being built at right angles to the shore line to secure the necessary wharfage and harbor room. This slip extends 2,000 ft. off-shore to the 22-ft. depth in the lake and 3,000 ft. inland. It is being closely lined along both sides with sheet piling to hold the sand in place, and will be dredged to the required depth.

The furnaces and stoves of the steel plant will be in single row along the west side of the slip, at a distance of about 750 ft. from the latter. Large traveling unloading machines will operate the length of the dock on that side and will convey the iron ore from the vessels to storage piles between the slip and the furnaces. These storage piles will be spanned by traveling bridges carrying grab buckets, which will handle the ore to stock piles or to cars for charging the furnaces, the general arrangement being the same as in several existing plants of the steel corporation.

The pier along the west side of the slip from the shore line to the inner end of the slip a distance of 3,000 ft., will have a concrete dock wall carried by heavy pile foundations. This wall extends from 3 ft. below Chicago city datum, the latter being on an average about 2 ft. below the lake level at Gary, to 10 ft. above that datum. It is 15 ft. wide at the bottom, has a vertical front face and is stepped on the rear face to a width of 5 ft. at the top. This wall rests on three longitudinal rows of piles spaced 6 ft. apart on centers, the piles in the rows being 3 ft. apart on centers. The piles in this portion of the pier are all at least 34 ft. long and are driven to at least 30 ft. below Chicago datum. The two outer rows are tied together at intervals of 6 ft. with heavy

iron rods; the outer row on the slip side are also anchored by rods, 44 ft. long, at intervals of 6 ft., to a waling on a fourth row of piles under the footing for the unloader tracks. Immediately inside of the outer row of piles is a row of triple-lap Wakefield sheet piling. This piling consists of 3x12-in. Oregon fir in 34-ft. lengths and is driven to a penetration of at least 30 ft. The outer row of round piles are under the toe of the dock wall and are cut off at the level of the bottom of the latter, 3 ft. below the Chicago datum, and are capped with a 12x12-in. oak timber. The other two rows of piles and the row of sheet piling are left with their tops protruding as they are driven and are imbedded in the lower part of the concrete wall.

The off-shore 2,000 ft. of the pier along the west side of the slip is a rock-filled timber and pile pier. For the first 600 ft. from the shore

This pier will be of the same construction as the off-shore portion of the pier along the west side of the slip, with the exception that the row of triple-lap sheet piling will be omitted in it. The space enclosed by the pier along the west side of the slip and by this outer pier was formerly covered with upwards of 22 ft. of water, but will be filled with sand to a height of 3 to 18 ft. above the water level and on this made ground will be erected a part of the steel plant.

No dockage facilities will be provided along the east side of the slip, for the present. From 500 ft. off shore to the inner end of the slip, in a length of 3,500 ft., a row of triple-lap Wakefield sheet-piling, consisting of 3x12-in. Oregon fir planks, 44 ft. long, is driven as a lining to retain the sand. This sheeting is protected on the outer side by a row of heavy round piles, driven 6 ft. apart on centers, which are capped on top and are held together by a 12x12-in. oak waling piece along the side that also serves as a fender. The second 500 ft. off-shore of the lining on this side of the slip



Section of Channel Showing Character of Sand.

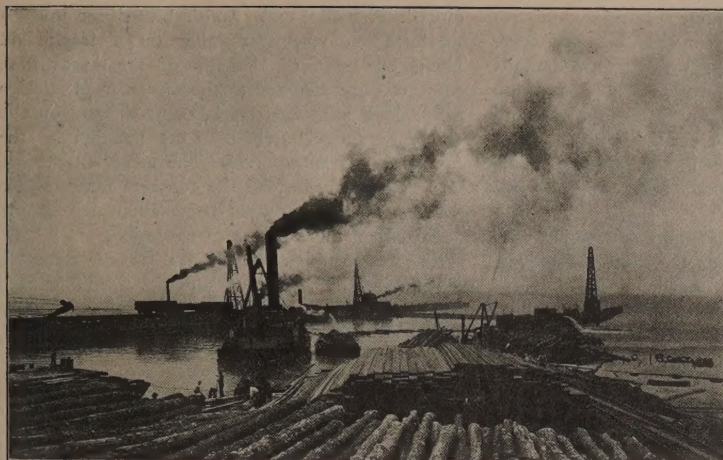
line this crib consists of two rows of closely-spaced, heavy, round timber piles with a minimum length of 45 ft. The rows are 12 ft. apart on centers and are tied together with two horizontal rows of iron rods attached to oak walings on the piles. A row of triple-lap Wakefield sheet-piling, consisting of 3x12-in. Oregon fir planks, 44 ft. long, is driven immediately outside of the row of round piles on the slip side. This sheet piling is protected by a third row of round piles, which are spaced 6 ft. apart on centers; these piles are capped with a 12x12-in. oak timber and are tied together near the top with a 12x12-in. oak waling piece, which also acts as a fender for the pier. The various rows of piles in the latter are driven to within about 12 ft. of the average water level in this section outside the natural shore line. The space between the two rows of closely driven piles is filled with broken stone from the natural bed of the lake to the top of the pier.

Beyond the 600 ft. of pier 12-ft. in width on this side of the slip, is 700 ft. that is 18 ft. wide and beyond that 700 ft. that is 24 ft. wide. The construction of these wider sections is the same as that of the 12-ft. section. At the outer end of this pier and the west side of the slip a rock-filled timber and pile pier, 2,000 ft. in length and 24 ft. wide, will be built to the west in the lake at right angles to the slip.

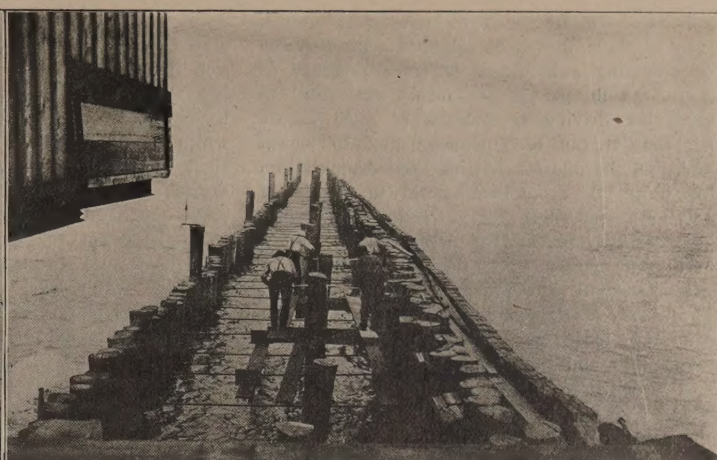
consists of a pier 12 ft. wide and of the same construction as the pier of that width on the west side; the next 300 ft. is 18 ft. and the remainder 24 ft. in width, all of the same construction as the pier of the same width on the west side. At the outer end of this pier, a return pier 24 ft. wide, is to extend 1,000 ft. to the east in the lake at right angles to the slip, and together with the pier along the east side of the latter will enclose an area of made ground, where the lake was originally as much as 22 ft. deep.

Construction of Harbor.—The low, flat beach and the location of the site of the harbor at the south end of the lake, where it is exposed to the full force of the extremely severe northeast storms which sweep the latter, rendered the early construction work on the harbor particularly hazardous. The sand dunes that formed the site of the inshore portion of the slip rose 15 to 30 ft. above the level of the lake and were only sparsely covered with scraggly oak trees and scanty vegetation. The sand in which the slip has to be excavated is extremely fine, clean and free from pockets of gravel or loam. Although not exactly quicksand, it flows so freely when wet that it is confined with difficulty, and, in fact, is almost as hard to hold when dry.

Construction of the harbor was commenced in July, 1906, when the contractor for this work,



Off-Shore Piers under Construction.



Piles for Off-Shore Rock-Filled Pier.

the Great Lakes Dredge & Dock Co. of Chicago, excavated into the site of the slip from the lake with a hydraulic dredge. The piling for a 600-ft. length of the pier on the west side of the slip, extending into the lake from the shore line, were then driven with a land driver running on the finished work. A 500-ft. length of the pier on the east side, also extending into the lake from the shore line was built about the same time. A breakwater consisting of two rows of piles driven close together, the rows being about 12 ft. apart and filled between with rock, was then thrown about half way across the slip at the end of 600-ft. length of pier on the west side. It was expected that floating equipment could work readily in the temporary harbor thus formed. The unusually large number of heavy northeast storms which occurred during the past winter and spring, however, greatly interfered with the progress of the dredging and pile driving. In fact, at times the floating drivers and the dredge were in much danger from the high surf that prevailed on the flat beach and carried into the temporary harbor without much reduction in force. In order that the floating equipment could be better protected, the breakwater across the slip was extended 40 ft. farther and a short breakwater built into the slip from the completed portion of the east pier, this second breakwater being far enough toward the shore from the first so an entrance from the lake was provided between the two. With this final temporary harbor arrangement the floating equipment can work on the off-shore pier construction during good weather and on the piers of the inshore section of the slip when the lake is rough.

After the preliminary dredging had been done with a 15-in. hydraulic dredge and the temporary harbor finished, the hydraulic dredge New York was brought in and is being used to handle the excavation of the slip. This dredge has an all steel hull which has a 40-ft. beam, is 110 ft. long, over-all, and 12 ft. deep. The superstructure is also entirely of steel, so the dredge is practically fireproof, and, as a matter of fact, is believed to be the only dredge of this type on the Great Lakes that is so constructed. The suction pipe for the pump of the dredge is swung from a 36 ft. A-frame with a 65-ft. boom at the forward end of the hull, which permits this pipe to be lowered to 35 ft. below the water surface. In the fine loose sand in which the dredge is at present operating no cutter is necessary. The dredge is provided with a 6-ft. cutter, however, which is operated by a 250-h.p. motor driven by current generated by a dynamo in the engine room.

The dredge is equipped with a special centrifugal pump having a 24-in. suction and a 24-in. discharge. This pump is driven at 300 r.p.m. by a 17x30x42x30-in. triple-expansion marine engine. Steam is supplied to this engine and to the other steam consuming units by two 13x13-ft. Scotch marine boilers operating at 170 lb. pressure.

Two shifts are employed on the dredge in the present operations so that pumping may be carried on continuously. Quarters are provided on board for 40 men, 36 men being required to run the dredge.

The 24-in. pipe line that extends from the dredge to the point where the sand is being deposited for filling is carried on the water by pontoons consisting of hollow 24-in. cylinders

built of boiler plates. These cylinders are made watertight and are built in lengths of 10 to 80 ft., depending on their location. They are used in pairs, one on each side of the pipe, the latter being swung from timbers attached to them. The pipe line is provided with flexible joints at intervals in order that bends may be made in the line without difficulty. The sand thus far has been pumped as much as 1,100 ft. from the dredge, the maximum distance to be reached by pumping being about 3,000 ft.

The preliminary plans covering the harbor construction estimated the excavation for the slip to require the removal of approximately 2,000,000 cu. yd. of material. Although under ordinary circumstances the dredge handles 8,000 to 12,000 cu. yd. in 24 hr., when working on the excavation for the inshore section of the slip the roots of the small oak trees interfere to considerable extent with the operation of the pump. Small roots, 1-2 to 1 1-2 in. in diameter, are found to extend as much as 30 ft. from the surface to reach the water in the thick stratum of sand which makes up the site, fine shoots branching from these tap roots in the vicinity of the water. These fine roots cannot be kept out of the pump, but collect in the latter in considerable quantities and have to be removed.

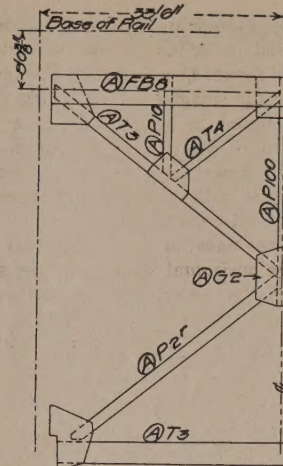
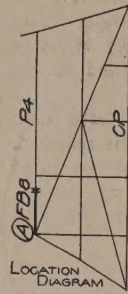
The excavation for the slip is made somewhat wider at the water level than is required for the slip itself, in order to facilitate the construction of the piers. In all, over 16,000 round piles and 5,000,000 ft., board measure, of lumber will be used in the piers. The piles and the sheet piling are all being driven with the assistance of hydraulic jacks. With the exception of the short length of each pier in which the piles were driven by land drivers, the work



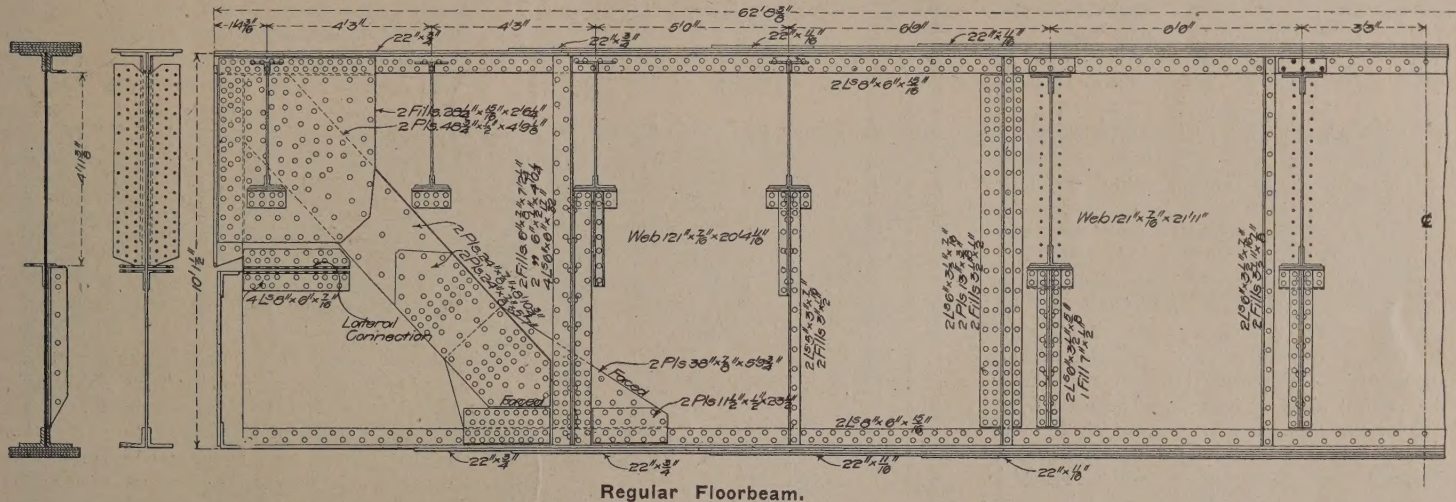
Two Views of Deep Excavation in Running Sand for the 10-Foot Water Intakes.

The Quebec Bridge Superstructure Details.— Part VIII.

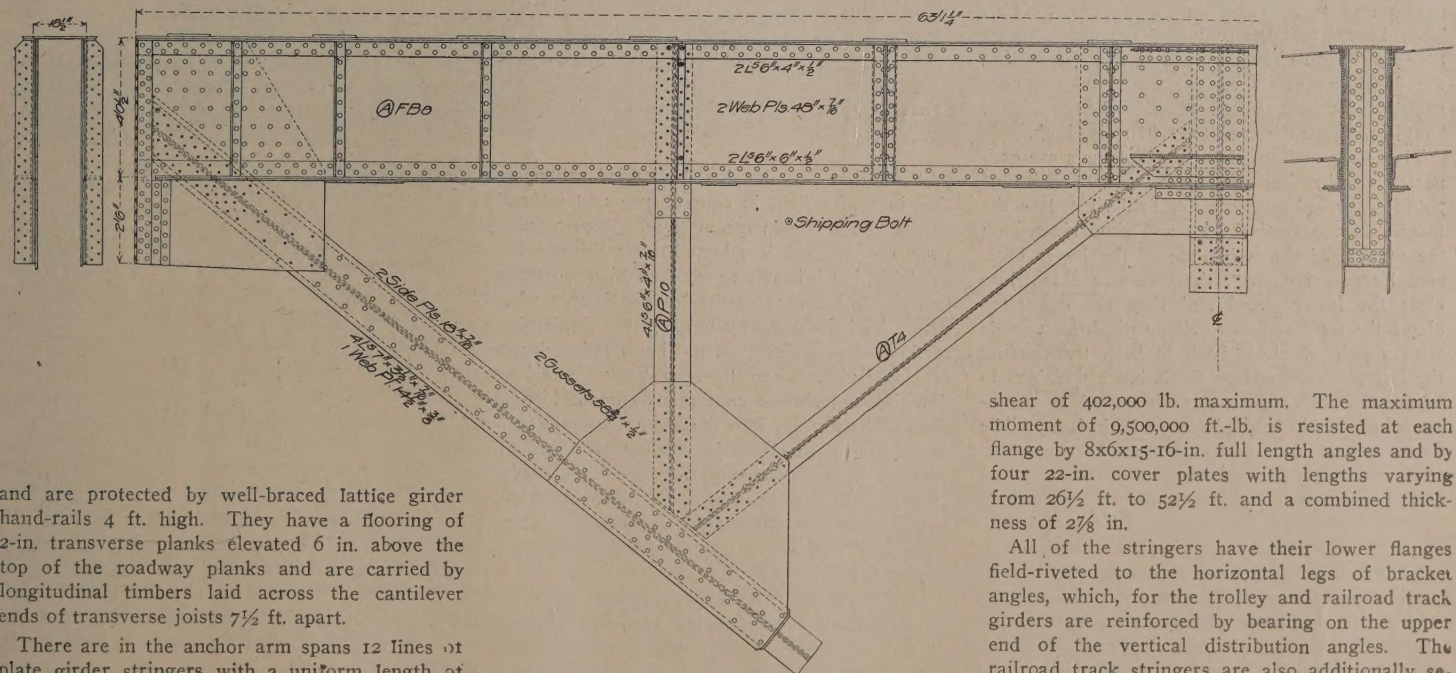
Floor System.—The floor platform projects 5 ft. 3 in. beyond the centers of the trusses giving it a total width of 72 ft. 3 in. and provides for a live load consisting of two 140-ton locomotives on each track $6\frac{1}{2}$ ft. from the axis of the bridge and for a continuous line of electric cars 30 ft. long, weighing 56,000 lb. each, 19 ft. each side of the bridge axis; and for a dead load of 6,200 lb. per lin. ft. due to floor construction alone. The railroad tracks are enclosed by vertical screens 7 ft. 4 in. high and the 17-ft. spaces between them and the truss clearances are floored with 4-in. diagonal planks spiked to 6x8-in. transverse joists, 18 in. apart on centers. Sidewalk platforms 5 ft. $1\frac{1}{2}$ in. wide in the clear extend through the trusses beyond the outer edges of the roadway platforms



Trussed Floorbeam Panel.



Regular Floorbeam.



Half of Upper Part of Trussed Floorbeam.

and are protected by well-braced lattice girder hand-rails 4 ft. high. They have a flooring of 2-in. transverse planks elevated 6 in. above the top of the roadway planks and are carried by longitudinal timbers laid across the cantilever ends of transverse joists $7\frac{1}{2}$ ft. apart.

There are in the anchor arm spans 12 lines of plate girder stringers with a uniform length of 50 ft., web connected to the floor beams with their top flanges just clearing the upper surface of the floor beam flanges. The four lines of railroad track stringers are 58 in. deep and are spaced 3 ft. 3 in. and 6 ft. 9 in. from the bridge axis. The 8 lines of roadway stringers, 38 in. deep are spaced 5 ft. apart under the trolley tracks and 4 ft. 3 in. apart outside of them. The track, as well as the roadway stringers, are braced in the usual way with zigzag top and bottom flange lateral angles and transverse frames.

In the shore end panels of the anchor arm

the lower chord is nearly horizontal and does not fall clear below the floor system; the deep, plate-girder floorbeams are therefore made in several cases to engage both the lower chord and the vertical posts, web-connected in the usual manner to the latter, notched slightly in the lower corner to clear the former and have their lower flanges flush with the lower flanges of the lower chord connected to them through the lateral connection plates. The effective connection is, however, made on the upper half of

the floor beam webs and provision is made for transmitting the lower flange stresses at an angle of 45 deg., to this point, through wide diagonal reinforcement plates riveted to the web plates in the sub-panels of the floor beams. These plates are thoroughly spliced to the bottom flange angles and although the latter are continued horizontally through the ends of the floor beam webs for the sake of stiffening them, the effect is substantially that of bending the flange angles up to the ends of the floor beams at this point. The floor beams at P1 and P2 resemble those at the adjacent intermediate panel points and have 7-16-in. web plates 10 ft. deep made in three sections, spliced together with four vertical rows of rivets to two $13\times\frac{3}{8}$ -in. cover plates. The end is reinforced and already described by four diagonal $24\times\frac{7}{8}$ -in. plates, and by two outside $48\times\frac{1}{2}$ -in. plates in the upper corners, making a total thickness of $4\frac{1}{2}$ in. to resist the end

shear of 402,000 lb. maximum. The maximum moment of 9,500,000 ft.-lb. is resisted at each flange by $8\times6\times15$ -in. full length angles and by four 22-in. cover plates with lengths varying from $26\frac{1}{2}$ ft. to $52\frac{1}{2}$ ft. and a combined thickness of $2\frac{7}{8}$ in.

All of the stringers have their lower flanges field-riveted to the horizontal legs of bracket angles, which, for the trolley and railroad track girders are reinforced by bearing on the upper end of the vertical distribution angles. The railroad track stringers are also additionally secured by top flange horizontal angle connections and by 30 field-driven rivets through vertical web-connection angles at each end. Each end of the floorbeam is connected to the vertical post by 106 field-driven rivets in six vertical rows of holes reamed to iron templates. The floorbeams weigh about 30 tons each and are shipped complete from the shop and handled in erection by special swiveling attachments which enable them to be delivered to the bridge parallel to its axis and to be revolved 90 deg. after being lifted from the cars by the overhang tackles, which swing them to position.

At post P₃, where the bottom chord is clear of the lower flanges of the floorbeam, the latter is a simple plate girder 121 in. deep with webs and flanges like those already described for the end floorbeams except that the ends are not fitted around the lower chords and are set square and riveted to the vertical post through their full depth, the connection being made with a pair of 6x8x $\frac{3}{4}$ -in. vertical angles, having two rows of rivets to each flange. The lower flanges of the stringers are seated on and riveted to the top flange of the floorbeam.

Near the river end of the anchor arm and the shore end of the cantilever arm the floorbeams virtually form the top chords of triangular trusses of which the bottom chords are formed by the main diagonals of the transverse braces below the floor. The floorbeams proper here consist of a box girder with two 48x7-16-in. full-length web plates, four 6x4x $\frac{1}{2}$ -in. flange angles, one full-length 26x $\frac{1}{2}$ -in. top flange cover plate and two full-length 7x $\frac{1}{2}$ -in. bottom flange cover plates. The stringers make butt joints on the center line of the top flange, where they are seated on riveted transverse plates. Pairs of 66x $\frac{1}{2}$ -in. vertical gusset plates are riveted to the insides of the webs at the ends and centers of the girders and project below the lower flanges to form jaws receiving the field riveted connections of the diagonals and of the center vertical posts.

The upper ends of the intermediate vertical posts are inserted between the girder webs and are field riveted directly to them. The ends of the floorbeams have pairs of vertical connection angles 6 $\frac{1}{2}$ ft. long, field riveted to the faces of the vertical posts or hangers. The main diagonals of the transverse bracing, which form the lower chords of the trussed floorbeams, have I-shaped cross section made with a 14 $\frac{1}{2}$ x $\frac{3}{4}$ -in. web plate two pairs of 7x3 $\frac{1}{2}$ x5-16-in. flange angles and two 18x7-16-in. flange cover plates. They intersect at the center of the panel, where they are cut to clear the vertical post supporting the floorbeam at its center point, and are connected to it and spliced together by a pair of 85x $\frac{1}{2}$ -in. flange cover plate, 7 ft. 10 in. long.

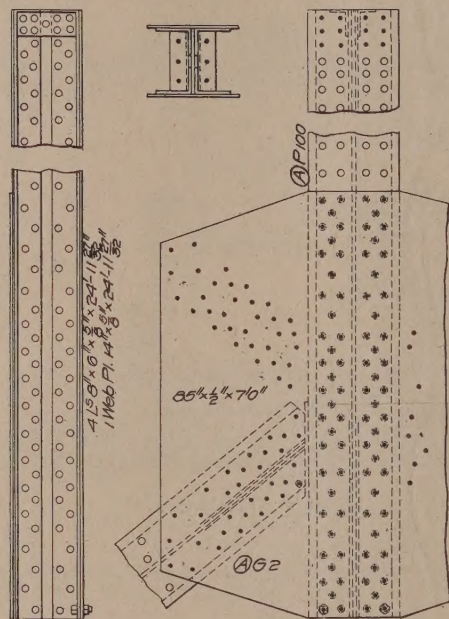
The lower ends of the main diagonals are connected to the feet of posts P₄ with pairs of 70 $\frac{1}{2}$ x $\frac{1}{2}$ vertical gusset plates field riveted to the flanges of the vertical post and shop riveted on the outside of the web plate of the lower horizontal transverse strut, the ends are notched to clear the lower chord and they are connected above the strut with an oblique diaphragm made with a pair of plates back to back transferring the lateral stresses from the X-brace members in adjacent panels which are connected to corresponding double bent plates on both faces. The lower lateral strut has a rectangular cross section made with two vertical 26x $\frac{3}{4}$ -in. side plates and four 3 $\frac{1}{2}$ x $\frac{3}{4}$ -in. angles latticed top and bottom.

(To be Continued.)

VENTILATION OF TUNNEL WORKINGS during the Euston extension of the City & South London Ry. received the careful attention of the engineers and contractors, who commissioned Mr. Harvey Collingridge to make periodical examinations of the air at short intervals. Whenever these showed that the working conditions were not up to the standard deemed necessary, immediate steps were taken to remedy matters by exhausting the foul air and supplying fresh. As the impurity in the air at the working face generally was two or three times as much as in the body of the tunnel, a little distance back, it was found necessary to keep the point of air discharge close up to the shield. It sometimes happened, also, that foul air collected at other points in the tunnel workings, and accordingly the whole line of the construction was kept under observation.

Electric Operation on New Haven Line.

The recent beginning of regular electric operation of passenger trains of the New Haven R. R., running into New York was an engineering event of unusual importance, although trial and training runs had previously been made so often that there was no question about the success of the new system. This company was one of the earliest pioneers in the field of heavy electric traction, and operated six short branch lines in commercial service by electricity for a number of years. Three of them, aggregating 33 miles in length, were equipped for overhead contact, and three of them, aggregating 39 $\frac{1}{2}$ miles in length, for third rail contact. All these lines were equipped with 500-volt, continuous current motors. The third rail was rather primitive in design and without protective devices, and so many injuries and fatalities followed its use



Center Connection of Trussed Panel, Quebec Bridge.

that the company abandoned all third rail operation in Connecticut in consequence and returned to the use of steam locomotives. Improvements over the method it adopted formerly are now available, but it is safe to say that this unfortunate experience was one of the leading factors which determined the company to adopt the single-phase method of propulsion on its line. This selection of single phase after the New York Central authorities had chosen continuous current locomotives to haul trains into the same terminal station has aroused considerable interest, and on this account it is desirable at the outset to explain just why the choice was made, this explanation being based on information furnished by Vice-President McHenry, of the New York, New Haven & Hartford R. R.

Had the company been limited in its inquiry to the equipment of the terminal section leading into New York City, which is now electrically operated, considerations of expediency would doubtless have led it to select continuous current motors taking current from a third rail. The company, however, recognized the great importance of its decision upon future extensions of electric service to other parts of its system, and its final decision was accordingly based upon a study of the road as a whole rather than upon the solution of the New York terminal problem only. Its main problem, therefore, was the selection of a system of electric transmission best adapted to its condition, combining in the greatest measure efficiency, flexibility, simplicity and lowest first cost.

In the case of the New Haven road this prob-

lem was rather unusual for reasons which will appear at a glance at any map of its system. The latter comprises a net-work of lines which makes the transmission problem one to be worked out for areas rather than for lineal distances, reversing ordinary conditions. Under such circumstances the economic radius corresponding to any initial potential will be considerably extended and the practical value of high potential transmission will be much increased. The company finally adopted the single-phase system for a number of reasons. The efficiency which it showed was 95 per cent. between the bus bars in the power house and the collectors on the cars, whereas the customary continuous current motor system has an efficiency of but 75 per cent. The flexibility of the continuous or combination system is impaired by the limited radius of the low tension distribution, requiring sub-stations at frequent intervals, and still further by the limitations imposed by the use of a conductor rail. The position and height of this rail regarding the track rail must be rigidly maintained, while the overhead conductor used with the single phase system may vary 8 ft. in height and 4 ft. horizontally without causing inconvenience. It was also believed that the cost of the single phase installation would be much less than that of a continuous current system, although it is too early to furnish positive comparisons of cost of construction and operation at the present time.

The selection of the frequency and voltage of the transmission system was a decidedly interesting problem. The choice of frequency was practically fixed by the manufacturing companies at 15 or 25 cycles. The lower frequency afforded a material reduction in weight, size and cost of motors, a reduction in conductor losses and induction disturbances, together with an increase in the power factor of the motors. On the contrary its adoption would have materially impaired the commercial value of the system as a whole, in preventing its extension for many other uses incidental to railway operation. The standard power and railway frequency in general use is 25 cycles, and as the New Haven company already owned a number of power houses generating current at this frequency for trolley roads and, in addition, had equipped many of its shops with 25 cycle motors, the adoption of 15 cycles would have required the abandonment of a large amount of standard apparatus or the use of costly and inefficient frequency changes. The lighting of buildings was an important factor, also, for 25 cycles is the lowest frequency at which carbon filament lamps in general use can be satisfactorily operated. It was also considered desirable to provide for operation in parallel with the 25-cycle generators already adopted by the New York Central R. R. Accordingly the practical effect of a change from 25 to 15 cycle apparatus on the New Haven system would be substantially equivalent to a break in gauge and under existing conditions it was decided that the practical commercial value of the higher frequency outweighed the more theoretically merits of the lower one.

In the final selection of apparatus another interesting consideration was the determination of the generating and transmission electromotive force of the system. It was believed at first that the best results would be obtained by transmitting power at the highest initial voltage for which generators could be safely designed, about 22,000 volts, sub-stations being provided at suitable intervals for supplying current at 3,000-6,000 volts to secondary circuits. As the two motors in each electric locomotive truck are permanently connected in series, current must be supplied to them at 560 volts through the trans-

former which is a part of the locomotive's equipment. It was finally ascertained, however, that great simplicity would result from cutting out entirely the intermediate sub-stations and line transformers and reducing the initial electromotive force to 11,000 volts, raising the ratio of the locomotive transformer to correspond. This change has caused a reduction in capital and operating cost and an increase in electrical efficiency which is most gratifying.

Before passing to some of the details of the equipment of the New York, New Haven & Hartford electrified line, attention may properly be called to a few statements given out by Mr. McHenry concerning the commercial aspects of electric traction. His investigations led him to believe that under favorable conditions there may be a sufficient saving in electric as compared with steam operation to pay interest and other fixed charges on the additional construction due to electrification and still leave a satisfactory margin to apply to dividends. Under general conditions, however, he believes it is altogether improbable that the direct saving resulting from the simple

but few locomotives which can generate sufficient steam to utilize their full cylinder tractive power at speeds in excess of 12 miles an hour. Consequently any increase of speed beyond certain limits can only be attained by sacrificing train tonnage in a corresponding degree. A division of the train mile cost by the lesser number of tons increases the ton-mile proportionately. The high cost of fast freight service is principally due to this effect of a diminishing divisor, while it would seem that electric traction should permit high speed without sacrificing commercial tonnage, as, with a relatively unlimited source of power at command, the maximum draw-bar pull permitted by the motor design may be maintained at all speeds. The commercial value of high speed in freight and passenger service is so great that the prospect of escaping the present penalties accompanying reduced train capacity becomes doubly interesting.

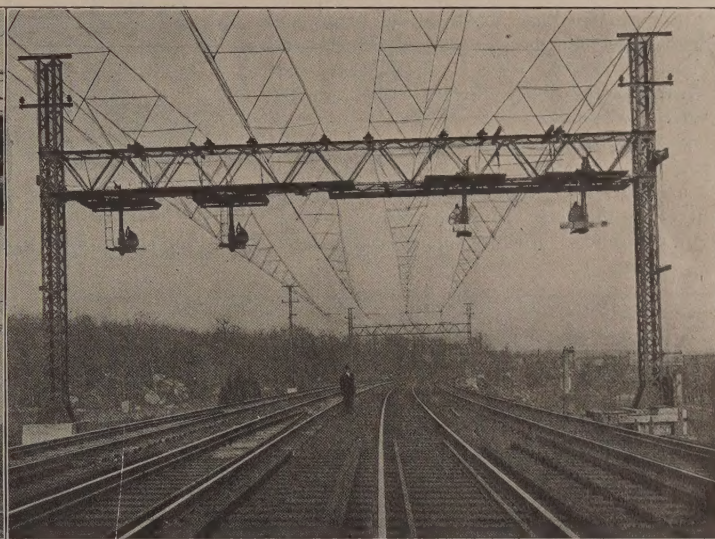
Hardly less important is the opportunity afforded at the opposite end of the scale, for the economical operation of trains of minimum capacity. The train capacity cannot be reduced, without

Coal can be delivered either by water or rail and an unlimited amount of salt water for condensing purposes is available from the river. By the erection of a dam about a mile upstream from the station, plenty of excellent boiler feed water has been obtained. The station is interesting as an example of plain-faced concrete blocks, made with crushed gneiss obtained in the excavation for the basement and condenser water flumes. In the boiler room the columns are steel, but all others are concrete. The runways for the traveling crane are of reinforced concrete. The boiler room is 160x110 ft., and the turbine room is 60x112 ft., the switchboard occupying a space 25x110 ft.

The current is supplied by three 3,000-kw. Westinghouse Parsons steam turbines and room is left for a fourth similar unit. The generators are wound for 3-phase current, but arranged to deliver both 3-phase and single-phase current. Their design was one of the most important technical problems of the entire undertaking. The former is required for delivery to the New York Central system to compensate for the energy required



Overhead Lines at Cross-over.



Intermediate Bridge with Signals.

substitution of electric for steam power will be sufficient to justify the additional investment and financial risk.

In changing the method of motive power on existing railways, the conditions are by no means so simple as in the construction of new lines, for in the former case a great amount of capital already invested must be sacrificed and the problems of adaptation to existing conditions are particularly severe. The transition stage in bridging over the gap between steam and electric operation is both expensive and difficult, as the change affects train lighting and heating, telegraph and telephone service, signaling and track maintenance. To secure the fullest economy it is necessary to extend the new service over the whole length of the existing engine stage, and to include both passenger and freight trains, and in this connection it is interesting to note that in the case of the New Haven Co., the passenger train mileage forms so large a proportion of the whole that no additional generating and transmission capacity will be needed when electric traction is extended to freight service.

Mr. McHenry believes that the application of electric traction to heavy railway service will probably be governed by more important considerations than its mere relative cost as a motive power under similar conditions. In steam service the weight and speed of trains are limited by the horse-power capacity of the locomotive which generates its own power, and there are

loss, below the point where the earnings equal the train-mile cost and if this cost cannot be reduced proportionately with reduced capacity, the inferior limit of capacity may be uneconomically large. In steam service the irreducible elements entering into the train-mile cost are so large that it is rarely possible to operate trains earning less than 40 to 50 cents per mile. On the other hand, electric service permits an extreme reduction of the train length to single car units, costing to operate but 10 to 15 cents per car mile. Hence the frequency of service may be increased and rates reduced, which in turn will react upon the volume of traffic, with a final result of increasing both gross and net earning. It may therefore be claimed for electric traction, in Mr. McHenry's opinion, that it will extend the limits of profitable operation of high speed heavy trains and also of light trains of low capacity.

A series of elaborate articles on all details of the electrical installation on the New Haven road is now appearing in the "Street Railway Journal," to which the reader is referred for complete official information in greater minuteness than is elsewhere available. The following notes are intended to give merely a general idea of the equipment.

The power plant is on the main line of the road on the bank of Mianus River, about one mile from Long Island Sound, and was designed and built by Westinghouse, Church, Kerr & Co.

to operate the New Haven trains over the New York Central lines.

A separate condensing outfit is provided for each turbine, consisting of an Alberger 3-phase counter-current surface condenser, a 2-stage dry air pump, a centrifugal circulating pump direct-connected to a Westinghouse engine and a Monitor hotwell pump, the speed of which is automatically controlled by a float.

Condensing water is furnished by a single flume constructed of timber with a lining of creosoted lumber, from the intake at the face of the dock to the shore line, and of concrete for the remainder of its length. A similar discharge flume parallels the intake flume under the turbine room, and then diverges from it to the river. Each condenser is installed directly underneath the corresponding turbine and over the discharge flume, while the circulating pumps are located over the intake flume, thus making all connections as short as possible. The pipes leading from the condenser to the discharge flume have a submerged discharge, thus decreasing the head under which the circulation pumps work. To prevent electrolysis of the brass condenser tubes, a motor-generator set has been installed with suitable controlling apparatus maintaining in each condenser a counter electromotive force slightly in excess of the electromotive force due to the galvanic action and the stray currents.

Steam is furnished by twelve 525-h.p. Babcock & Wilcox water-tube boilers, set in batteries of

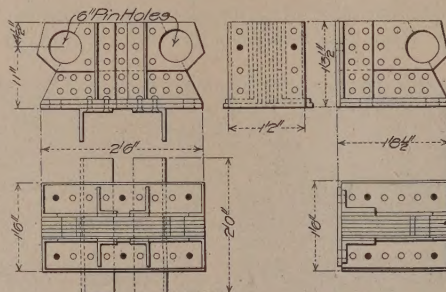
two each and arranged with eight boilers on one side and four on the other, separated by a 21-ft. firing floor. Provision is made for four additional boilers and to take care of the fourth turbo-generator which may be installed later. The boilers have Roney mechanical stokers and Babcock & Wilcox superheaters to deliver steam at 200 lb. pressure and 125° superheat. The boiler settings are completely enclosed in an external steel casing to render them impervious to air leakage. There are three Green fuel economizers.

Water is pumped at the dam at Mianus by means of two single acting vertical triplex pumps driven by 3-phase motors. One of these is able to supply the plant when it is running non-condensing and the other to supply all the fresh water needed when running condensing. Both pumps are operated by current from the power station. The water is forced through a 10-in. main to a circular reinforced concrete reservoir holding 600,000 gal., just outside the power house. From it the make-up water flows by gravity to two 13,000-gal. feed water tanks in the basement of the boiler room, which also receives the discharge from the hotwell pumps. The water is then drawn from these tanks by the pumps and delivered through the feed water heaters and economizers into the boilers. An auxiliary supply may also be obtained from a main of the Greenwich Water Co.

Coal received by water is unloaded from the barges by a clam-shell bucket which raises it into a hopper of 15 tons capacity at a height of 55 ft. above the dock. From the hopper it drops by gravity into a crusher and from the latter

A steam main is carried over the boilers on each side of the boiler house, each of the two mains crossing over to the opposite side at the center of the boiler room; provision is made for cross-connecting these two mains. From the boiler room the mains extend through the partition wall into the turbine room, thence downward into the basement where they connect to a header under the floor. A separate main is provided for the steam-driven auxiliaries, which are all designed to use superheated steam.

The main cables from each generator are run up to the switchboard gallery and thence through circuit breakers, down to the high-tension busses under the gallery. One bus supplies the 3-phase current to the Port Morris feeders and the other principally single-phase currents for the New Haven locomotives. When a bus section, or the entire bus is used for supplying single-phase propulsion current, one leg is grounded directly to the track rails of the right-of-way through suit-



Skewback Hinge Pedestals, Plate Girder Arch.

tures on each truck, with their corresponding compensating field coils, are joined permanently in series and operated at all times as a unit. For direct-current work, the two motor units of each locomotive are connected in series at starting and in parallel at full speed, while for alternating current work the two units are operated separately from the secondaries of the step-down transformers at variable voltage, so that they are practically joined and parallel at all times. The locomotives may be controlled from either end by a master controller. On the New Haven portion of the line, current is taken from the overhead trolley line by means of a pantograph collector, while on the New York Central portion of the route provision is made for a lower overhead direct current pantograph trolley and third rail shoes. The locomotive measures 36 ft. 4 in. over the bumpers and weighs approximately 85 tons. It is capable of handling a 200-ton train in local service on a schedule speed of 26 miles per hour, with stops averaging 2 miles apart, making in such service a maximum speed of about 45 miles. It can also handle a 250-ton train on through service with a maximum speed of about 60 miles per hour. With heavier trains it is planned to couple two or more locomotives together and operate them in multiple. Details of the locomotive were explained at considerable length in *The Engineering Record* of March 24, 1906.

The overhead construction is shown in the accompanying illustrations. It is carried by supporting bridges of various lengths, accommodating 4 to 12 lines without intervening posts be-



100-Foot Plate Girder Arch Spans over Carnegie Lake.

drops into steel cars in which it is weighed. The cars are drawn by cable up an inclined single-track railway of 13 per cent. grade into the top of the boiler room. There the coal is discharged into a hopper, whence it is delivered to two flight conveyors running the length of the boiler room. Openings in the bottom of the conveyors discharge coal through spouts to the stoker hoppers of the boilers. The flight conveyors have a capacity in excess of the coal required for the boilers and the surplus fuel is discharged at the further end of the boiler room into a storage bin below the boiler floor. Coal received by rail is dumped directly through a chute into this bin. When the boilers are supplied from this bin, the coal is discharged from it by gravity into a crusher, thence into a bucket conveyor in a tunnel below the bin, by which it is delivered to the flight conveyors above the boilers, and thence through the chute to the stoker hoppers. The ashes are dropped by gravity from the dumping grates of the stokers into chutes leading to cars running on tracks in the basement. These cars at present carry the ashes for use as a filling of the low ground in the neighborhood of the station.

able switches; another leg supplies the outgoing feeders, which are run in duplicate, connecting directly to the trolley and forming the complete single-phase circuit; the third leg of this bus is also connected to a feeder carried along the right-of-way to supply power for local purposes, and completing the 3-phase circuit along the line.

The locomotives used for hauling the trains were designed jointly by the engineers of the Westinghouse Electric & Mfg. Co., the Baldwin Locomotive Co. and the New York, New Haven & Hartford R. R. Co. They have two 4-wheel trucks, spaced 14½ ft. apart between centers, each truck having four 62-in. driving wheels. The motors, one for each axle, are of the gearless type and the methods of suspending them and transmitting the torque to the drivers are unusual. The armature winding is of a well-known direct current type, but is closed on itself and indirectly connected to the commutator through preventive leads, which are a feature of the Westinghouse design of single-phase motors. These leads serve the same function as the preventive coil used in alternating current work when passing from one tap to another of a transformer. The two arma-

tween tracks, and by heavier anchor bridges of which details have already been published in this journal. The main conductors are paralleled by two auxiliary feeder wires, for feeding around any section that may be cut out of service, and provision is made for two power feeders connected to the third phase of the generating system, and, on top of each post, for a three-phase circuit. The bridges are uniformly 300 ft. apart, and on sharp curves guy poles and pull-over wires are used to give the necessary curvature at intermediate points.

SNAILS IN THE WATER MAINS of some districts in Chicago have been causing considerable trouble. Evidently these snails originally entered from the lake and are now living in those pipes, which have only a small flow through them. In many cases service pipes have been stopped up by the shells, which have become tightly wedged inside them. These service pipes have been pumped out by force pumps and the main flushed through fire hydrants. In this way a large number of the shells have been removed. Blow-off branches to the sewers and screens on the mains will be tried as remedies.

A Plate Girder Highway Arch Bridge.

Harrison St., in Princeton, N. J., is carried across Carnegie Lake at a height of about 14 ft. above water level on a bridge of four three-hinge plate girder arch spans of 93 ft. 4 in. Several alternative designs for the superstructure were considered, and estimates were made for ordinary plate girders and for lattice girders, but the arches were adopted on account of the increased headway secured by their use, for the minimum elevation, and because of the much more attractive appearance presented by them. The weight, although somewhat less than for ordinary plate girders is a little larger than for lattice girders of the same span.

The spans are duplicate and are independent of each other except that the pedestals on the three intermediate piers are continuous. Each span has two 3-hinge arch ribs 20 ft. apart on centers which have a rise of 7 ft. from the skewback pins and a depth of 2 ft. at the crown and 9 ft. at the skewbacks. Each semi-arch rib was shop riveted complete, forming a single unit about 47 ft. long and weighing about 9,500 lb.

26 in. deep are web connected to the arch ribs with their top flanges under the top flanges of the ribs. They carry three lines of 12-in. I-beam stringers with shelf and web connections and support the continuous reinforced concrete floor slabs which also rest on the top flanges of the arch ribs and project a few inches beyond them. The slab is made with 1:2:4 concrete reinforced with a single layer of No. 10 expanded metal of 3-in. mesh. It has a uniform depth of 6 in. except over the stringers where it has a 1-in. extension to rest on their top flanges and at both edges where it is integral with the curbs, in which the hand rail cast-iron posts are firmly embedded. The slab is covered with macadam, crowned to a thickness of 5 in. on the center line.

The skewback pins engage half holes in single-web pedestals which, on the intermediate piers, are symmetrical about the center line and receive both adjacent spans, to which they are locked by single projecting reinforcement plates with full holes. A pair of 6 x 6 x 5/8-in. angles 2 ft. long are riveted across the base plate with their vertical legs projecting downward and embedded

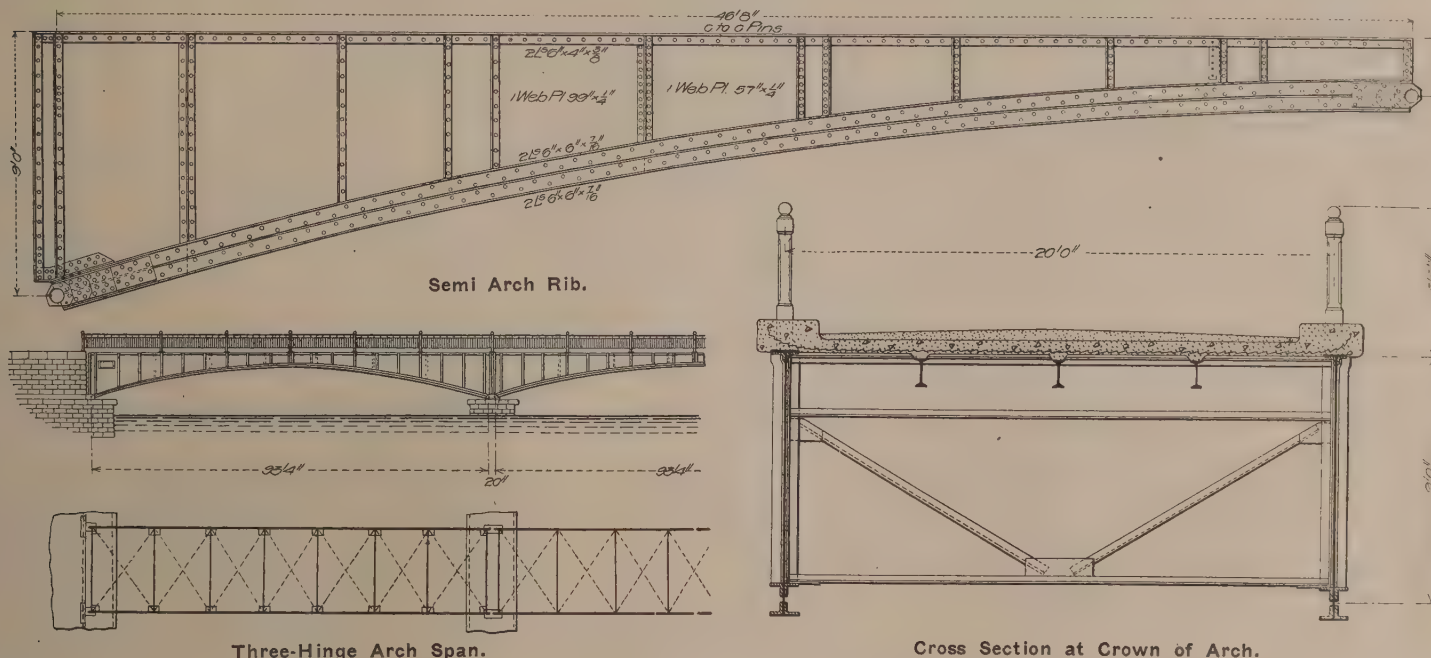
of 17,000 lb. in tension and 10,000 lb. shear on web plates. The dead load per lin. ft. consists of 800 lb. of steel and 2,200 lb. of floor, while the live load is calculated at 100 lb. per square foot or for a 15-ton road roller.

When the bridge was erected there was no water under it except a small creek between two of the piers. Two ginpoles were set up on the dry lake bottom and erected the semi-arch ribs, holding them in position until connected and braced to be self-supporting and stable. All materials were delivered by wagons at the feet of the piers and hoisted by the gin poles or by hand.

The bridge was designed by the American Bridge Co., and was fabricated in its Trenton plant. The United Construction Co., Albany, N. Y., was the contractor for the erection of the superstructure.

The Protection of Concrete and Iron.

The protection of concrete and iron exposed to the portion of the water of Frankfort, Germany, drawn from driven wells is necessary on account of the large amount of oxygen and free



It really corresponds to a spandrel braced arch truss in which the effective member is the curved lower chord which is the segment of a parabola. It has an H-shaped cross section with a uniform area built up with four 6 x 6 x 7/16-in. full length flange angles and a 1/4-in. web plate which, forming the spandrel bracing, projects beyond the lower chord to the horizontal upper flange of the arch rib which is made with two 6 x 4 x 3/8-in. angles.

The web is spliced by double vertical rows of rivets through pairs of 6 x 3/8-in. cover plates and is divided into panels about 5 1/4 ft. long by pairs of 3 x 3-in. vertical web stiffener angles. The arch rib is reinforced at both ends by pairs of pin plates to give the required bearing for the 6-in. skewback pins and the 5-in. crown pins. The bearings are made with half holes, except that the outside reinforcement plate is continued far enough beyond the end of the rib to receive a full hole and lock it to the pin.

The arch ribs are connected at both ends and at six equidistant intermediate points by lower horizontal struts and vertical transverse X-bracing of the ordinary type made with single light angles riveted to vertical web stiffener angles adjacent to those at the regular panel points. The panels between have X-brace lateral angles in the plane of the lower flange. The plate girder floor beams

in the concrete so as to develop considerable resistance to any unbalanced horizontal thrust which might temporarily occur during erection or from very irregular loading. Since the horizontal component of the reaction is greater than the vertical component, the pedestals at the abutment ends of the bridge, which receive only one skewback hinge each, are made with both vertical and horizontal bearing plates and the former engages the outer flanges of a grillage of three 6-in. I-beams 4 ft. long embedded horizontally in the concrete abutment.

The thickness of the floor slab is increased at the ends to 7 in. and rests and slides freely on a seat moulded in the top of the abutment back wall with its surface and that of the floor slabs thoroughly painted with hot asphalt to prevent adhesion and to facilitate longitudinal motion. The roadway is protected by neat fences in the planes of the arch ribs which have at panel points cast-iron posts carrying the 2 x 3/8-in. top and bottom bars, 33 in. apart, the 3/4-in. square vertical bars 5 1/4 in. apart and a top rail made of a 3 1/2-in. pipe, with a horizontal 2-in. channel, flanges up, riveted to it.

The bridge is made of railway bridge grade open hearth steel corresponding to the requirements of the manufacturer's standard specifications and proportioned for maximum unit stresses

acids in the supply. These have a destructive effect on iron and other metals, the iron undergoing a softening change which continues to such a point that it can finally be cut with a knife. The concrete walls of a large reservoir having a dense surface coat of cement mortar were also attacked by this water, and the department accordingly undertook an elaborate series of investigations to determine the degree of protection against such action afforded by various compounds on the market. After experimenting for some time, none was found sufficiently resisting to this peculiar water, but Dr. Carl Roth, the chemist engaged on the investigation, devised a compound which gave much more satisfaction, lasting without apparent injury long after other substances had completely failed. The success of this compound has led to its being placed on the market under the name of "Inertol" by Mr. Paul Lechler, of Stuttgart. The concrete is best rubbed off with felt disks rather than steel trowels, and must be perfectly dry and preferably warmed before the inertol is applied. The latter should be given an opportunity to dry thoroughly before water is allowed to come in contact with it, for otherwise the water will acquire the odor of carboic acid and consequently be spoiled for drinking purposes.

A Low-Cost Concrete Railway Culvert.

In line with the policy of the Nashville, Chattanooga & St. Louis Ry. to fill all trestles instead of rebuilding them, whenever possible to construct culverts for the waterway required, it was decided in 1905 to fill Trestle 55.7 on the Nashville Division.

This trestle, known as Yellow Bank trestle, has a total length of 922 ft., with the track at an elevation of 76 ft. above the valley. There is no stream under the trestle except during the wet season, when a large volume of water passes through. After making a survey of the drainage area above the trestle to determine the size of waterway required, a 12-ft. full-centered concrete arch culvert, with 6-ft. side walls, was decided upon as being ample, and plans were prepared for the same.

In designing the plant for building the culvert, advantage was taken of the height of track above the valley, so that as nearly as possible all material moved by gravity from the cars in which it was shipped until finally placed in position in the wall. Slag and sand were shipped in drop-bottom cars and unloaded into bins constructed in the trestle. These bins were built with hopper bottoms, ending in chutes that led to a wheeling platform, which occupied the space between two of the trestle bents and extended over a concrete mixer placed just outside of the trestle. A cement house was erected alongside the trestle, level with and adjoining the platform. An inclined chute led up from the opposite end of the cement house to an unloading platform at track level, so that the cement, which was shipped in sacks, could be handled directly from the cars to the chute, and thence by gravity into the house.

The sand and slag were fed by gravity into wheelbarrows through gates controlled by levers to regulate the amount taken, and were then dumped into a hopper directly above the mixer. Two men wheeled slag to the mixer, one man wheeled sand, and one man wheeled cement. With the mixer in operation these men had to load the barrows and make a round trip, including dumping the load into the hopper, in about one minute's time. The maximum wheeling distance from the chute to the hopper was 23 ft.

A water supply was secured by sinking a well in the drainage channel just below the trestle, the water from this well being pumped by means of a gasoline engine into a tank placed on the trestle. From the tank a continuous stream of water was fed into the mixer through a flexible connection, a valve so regulating the flow that the necessary amount was delivered in the time required to mix a batch.

A drop-bottom car of 1 cu. yd. capacity, running on 30-in. gauge tram tracks, conveyed all concrete from the mixer to the wall. The hinged bottom doors of this car were held closed with a latch, which was withdrawn by means of a lever at the side of the car to dump the load. After dumping, the bottom doors closed automatically, and were latched by the lever above referred to.

A trestle spanning the entire culvert was constructed out of old car sills, with the deck at a sufficient height to clear the top of the arch when completed, and longitudinal tracks were built on the same directly above each wall. This arrangement permitted dumping the concrete into its final position in the wall without rehandling. Two small turntables connected the longitudinal tracks with a cross track that extended to the mixer. Three men were required to handle the car, and they made the round trip when going to the extreme end of the culvert in about

3 min., the mixer in the meantime discharging into a small hopper, which discharged into the car upon its return.

In order to provide expansion joints, the culvert was built in three sections, both walls of a section being brought up together. After reaching a point 2 ft. above the spring line, one of the tracks was removed and the other shifted to a position directly above the center of the arch, so as to reduce the handling of concrete to a minimum.

The concrete consisted of a 1:3:6 mixture, slag and stone being used as the aggregate. It was intended to use slag exclusively, but delays in shipment of the same necessitated substituting stone for about one-third of the work.

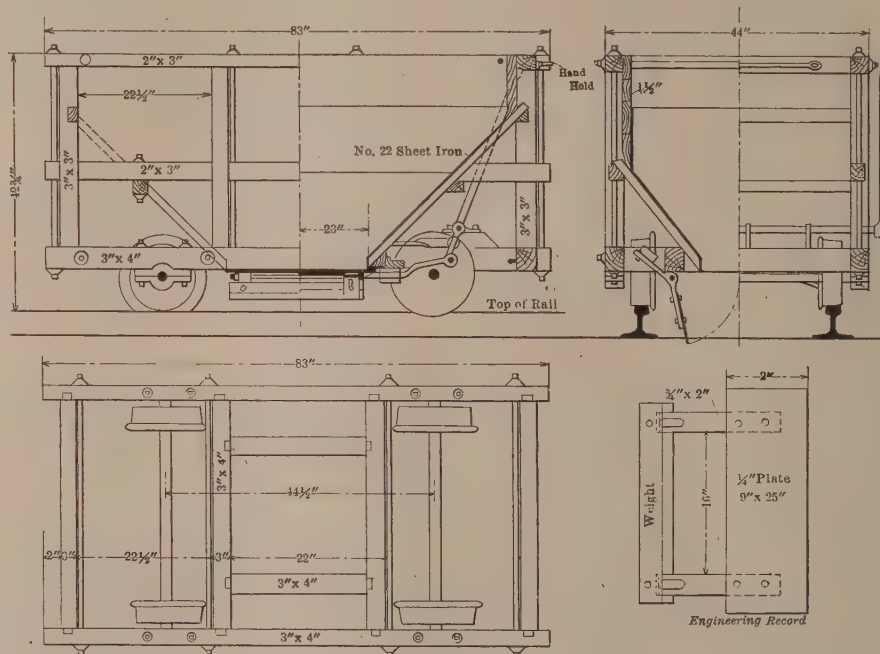
All excavating for the foundation, unloading of material, mixing and placing of the concrete, was done by one of the regular concrete forces of the railway, consisting of four white men and thirteen negroes, the rate of pay being as follows: 1 foreman, \$3.50; 1 mason, \$3.50; 1

capacity of the machine, one-half minute being required to mix the concrete, and at least that much time in charging and discharging it.

A No. 5 Chicago improved cube mixer, operated by a Bates & Edmunds Motor Co. gasoline engine, was used, and gave satisfaction; but a larger size would have been more economical, as all cement had to be measured, the amount required for each batch being two-thirds of a sack. This measuring required one additional man.

Another objectionable feature of the small machine is the size of the charging hopper, which causes a tendency to choke if the entire contents of a wheelbarrow are dumped into it instantaneously. To the cost of one man required to keep the hopper open should be added the delay in charging the mixer, which materially reduces the daily output of the same.

A comparison of the cost of this culvert with those of culverts on the same road built under quite similar conditions shows a large saving



Concrete Car Used on Nashville, Chattanooga & St. Louis Ry.

carpenter, \$2.25; 1 blacksmith, \$2.05; 5 laborers, \$1.20; 8 laborers, \$1.10; a total of \$26.10 per day. Usually this gang builds the forms as well as doing all other work; but owing to the size of the culvert and the haste to complete concreting before cold weather, the forms, arch centering, bins, tram trestle, and working platforms were erected by a bridge crew of white men, whose pay ranged from \$1.75 to \$2.25 per day. This slightly increased the cost of building forms, but secured rapid construction of the culvert.

The concrete gang moved to the work on Sept. 12, excavated 853 cu. yd. of earth, unloaded the material for and mixed and placed 1,217 cu. yd. of concrete, removed the forms and bins, loaded all timber used in construction, and moved away on November 9. During this time they lost three days on account of rain and closed down one day for lack of material.

The mixer was in operation 194 hours, and mixed 7,702 batches, or at the rate of one batch every 87 sec. during the entire time it was in operation. During the last ten days it mixed a batch every 78 sec. while running. The best short record made was 291 batches in 5 hours, being one batch every 63 sec., or at the rate of 58 batches, equal to 9.2 cu. yd. of concrete in place per hour. This is about equal to the

both in the labor and material items, the saving in the latter case being due to the use of slag. The concrete amounts to 1,217 cu. yd. and cost on an average \$4.32 per yard, as against \$5.88 per yard for the next lowest cost culvert which contained 406 cu. yd. of concrete, and \$6.27 per yd. for a culvert containing 986 yards. The cost of the labor for the Yellow Bank culvert was \$1.64 per cubic yard, for the second culvert \$2.97, and for the third \$2.97. These costs include excavation, mixing and placing concrete, building and removing the forms, and the back filling.

The cost of the concrete alone including forms, material, and labor of unloading, mixing and placing was \$3.71 per cubic yard for the Yellow Bank culvert, \$5.16 for the second one, and \$4.96 for the third, the labor items in these amounts being respectively \$1.08, \$2.11 and \$1.67 per cubic yard of concrete.

The reduction in labor cost was due largely to the use of a mechanical mixer, although the large yardage and the economical methods of handling material were factors in bringing about the reduction. The total cost of the culvert was \$5,258.13.

The account of the work here given was presented in a paper by Mr. W. H. Whorley to the Engineering Association of the South.

The Kern River No. 1 Power Plant of the Edison Electric Co., Los Angeles.—Part II.

By C. W. Whitney.

Power House.—The pressure tunnel emerges from the side of Mt. Breckenridge at an elevation above the sea level of 1061.95 ft. Directly in front of this point and slightly up-stream there was a boulder-covered wash protected by a bend of the river and bordered by a large mass of bed rock standing at the edge of the main channel of the river. This space was chosen as the power house site. The intake of the Power Transit & Light Co., of Bakersfield, is directly across the river and it is necessary to discharge the water from the wheels in such a direction and at such an elevation that it will flow by gravity into their intake.

The Kern River is subject at times to very considerable floods and the elevation of the header pipe and consequently of the water wheels was made sufficiently high to permit of running the units even when the stream was at its maximum flood.

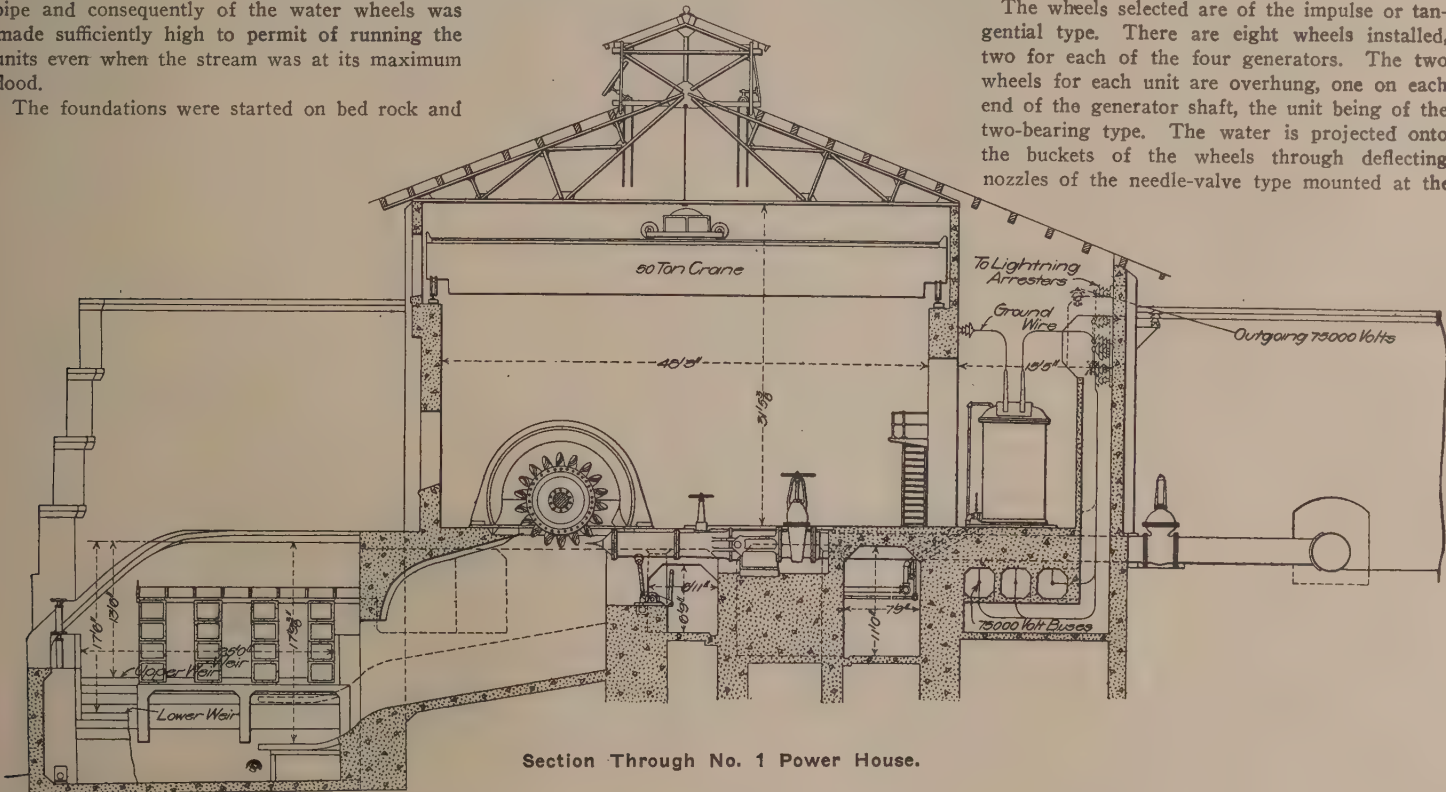
The foundations were started on bed rock and

by exceptionally high water early in the year and after that time all necessary make-up sand was hauled from the mouth of the canyon about 2½ miles distant.

The upper part of the machine foundations carries a small amount of reinforcement. The large block of masonry back of each water-wheel deflector is heavily reinforced and tied into the main foundation blocks. The crane rail arches for the interior wall are reinforced concrete beams, with the exception of the long span above the switchboard, which contains an I-beam girder. By reason of the length of the building and the importance of the work no account was taken in its construction of the additional strength resulting from the continuity of the beams, the bridging effect of the crane rail, and its cushioning timbers, nor was any allowance made for the 12-in. curtain walls which fill in in places below this beam. The north wall, however, is a 12-in. curtain wall

years ago, no plant of its size had been constructed for impulse wheel work. Units exceeding 2,000 kw. in output were extremely rare and for a long time it was supposed that 2,500 kw. units would be selected for this station. When, however, specifications were issued many larger units were in successful operation and prices were requested on machines of 4,000 and 5,000 kw. normal output. No difficulty was anticipated nor was any experienced in securing generators of this size. Considerable attention was given to the water-wheel equipment. Some manufacturers were willing to undertake the building of wheels having an output of 10,000 h.p. each from a single nozzle, but the large size required and the extremely crowded placing of the buckets rendered necessary if the unit was to be of reasonable dimensions, seemed to the officials to indicate that such a construction would be less efficient than the arrangement finally purchased.

The wheels selected are of the impulse or tangential type. There are eight wheels installed, two for each of the four generators. The two wheels for each unit are overhung, one on each end of the generator shaft, the unit being of the two-bearing type. The water is projected onto the buckets of the wheels through deflecting nozzles of the needle-valve type mounted at the



Section Through No. 1 Power House.

cemented boulders, low enough to avoid any possibility of the power house being undercut by floods and were carried up as walls in such a manner that no important machinery rested on floors placed on backfill. All spaces between these walls except those which could not be utilized on account of their falling so low as to be subject to flood, were filled in with compact backfill from other portions of the work.

The available area was so crowded that it was necessary to make a deep excavation in the hillside to accommodate the inner or eastern end of the building. The débris from the cut and from the tail-races was wasted on the south side of the building as a dump upon which the header and branch piping from the pressure mains were placed. On the north side of the station the spoil bank filled in a triangular area of the flat wash, raising its entire area above maximum high water and producing a bulkhead which will protect the power house from any possible flood.

The foundations proper are of monolithic concrete. The rock and part of the sand for the aggregate were secured by crushing granite boulders excavated from the site, as well as a large amount of rock which was lying on the pressure tunnel dump. Additional sand was secured for a time from various small bars in the river adjacent to the power house. These were, however, covered

reinforced with heavy pilasters and this contains only sufficient reinforcement to render it reasonably secure against shock and vibration. The south wall of the building is of a cellular construction for about two-thirds of its height in order to provide wiring ducts for the 60,000 volt wiring connections. This wall also contains only nominal reinforcement. Between this wall and the interior crane wall, a space 15 ft. wide, a series of transverse partitions break up the area into transformer, switch and switch-board rooms. The transformer rooms are open up to the crane beam to permit of wheeling the transformers out under the main crane. The crane rail columns are not highly stressed and have no hooping whatever. A 50-ton electric traveling crane with a 50-ft. span, built by Maris Bros., serves the entire machine room. The switch-board space carries a deck 8 ft. 6 in. above the main floor level upon which the control board is mounted.

The roof of the building is of galvanized iron laid on wooden purlins, which are carried on steel roof trusses of 52 ft. 1 in. clear span. The internal length of the machine room is 164 ft. and its clear width 66 ft. 6 in. The generating units are located along the north side of the station 78 ft. from the center of the pressure header.

Water Wheels.—At the time tunnel work on the Kern River No. 1 plant was commenced five

end of the 28-in. branch pipe. By means of these deflecting nozzles and needle valves the discharge from the tip of each nozzle can be accurately regulated without altering the form of the jet to any appreciable extent. The wheels are designed to run at 250 r.p.m., and the two wheels on each unit are guaranteed to deliver 10,750 h.p. to the generator shaft.

The nozzles are provided with hand-adjustable needles and are arranged to be deflected by the governor automatically, or by the latter's hand-regulating device. By deflecting the jet, instead of regulating its discharge by adjusting the needle with the governor, it is possible to secure a constant velocity of water in the pipe line, as well as a constant discharge of water into the tail-race, even when the plant is operating with heavy fluctuations of the commercial load.

The nozzles are of the best quality of cast steel. Special attention may here be called to the design, which has a number of new features. Each nozzle consists of two Y pipes, flanged together in such a way that the whole nozzle has a diamond or bifurcated shape. The up-stream end of the nozzle forms the movable part of the knuckle or ball joint, and the down-stream end carries the nozzle tip. By making the nozzle diamond-shaped, the following advantages are claimed by the manufacturers:

1. The center of the jet corresponds to the center of the inlet pipe, therefore any reaction from the jet upon the needle and nozzle is not eccentric. This is of importance with deflecting nozzles, where any variable reaction upon the governor should be avoided.

2. As the two branches of the Y join at an ample distance from the nozzle tip, the water has time to gather concentrically around the needle under an absolutely uniform pressure. The result is that the jet leaves the nozzle tip at a high velocity and without disturbance.

3. Due to the fact that the jet leaves the nozzle tip uniformly, the needle is axially balanced and not subject to any vibration.

4. The needle stem, not being subject to any bending, need not be made slender and flexible, but is made of very substantial form. The end of the stem projecting through the front Y pipe is of smaller diameter than the stem. The differential room thus formed can be put under adjustable water pressure. This pressure tends to close the needle and puts all pins and links of the connection to the hand adjustment under slight pressure in the closing direction. By this any rattling of the needle is prevented.

The up-stream end of the nozzle, forming the movable part of the ball joint, is hooked into the stationary part, or swivel head. This swivel head is heavily bolted to the concrete foundation, as it has to take up the full pressure of 375,000 lb., tending to pull the nozzle away downstream. This pressure is taken up by two steel trunnion pins carefully fitted into their bearings and provided with suitable lubrication.

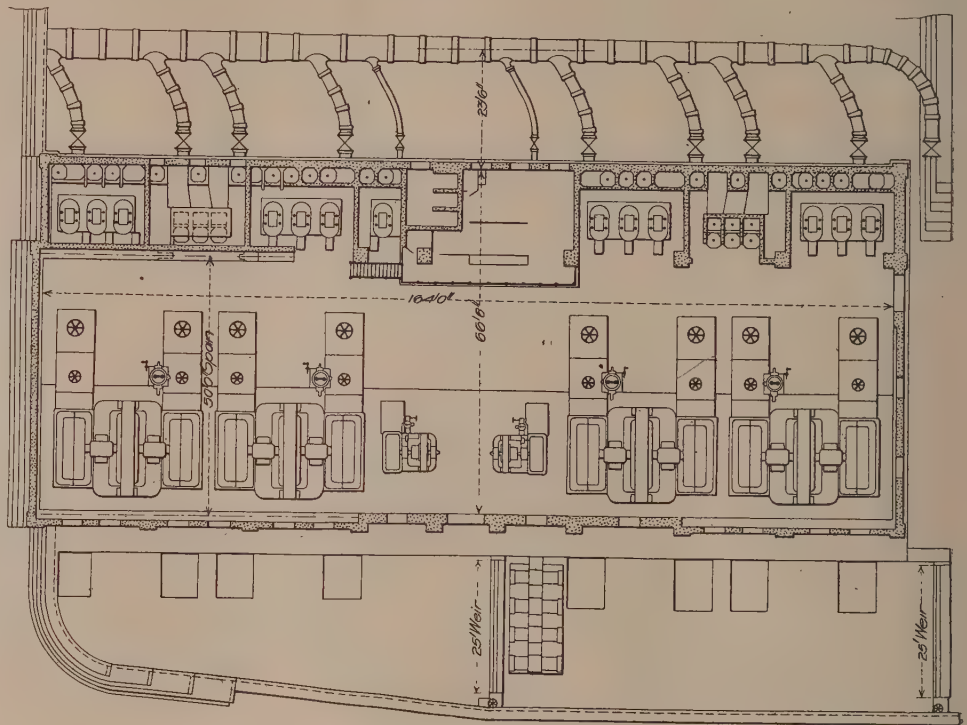
The nozzles are equipped with needles for adjusting the size of the stream by hand. For convenience in construction and to permit of balancing them for back-thrust the needles are straight backed, running through a guide-sleeve of their full diameter into a balancing chamber supplied with water from the pressure side. The needle then reduces to a stem and passes through a second stuffing box beyond which the control links are attached. The needles are torpedo shaped, being 8 ft. long 12 in. in diameter at their maximum and $8\frac{1}{2}$ in. in diameter at the stem. The tip is about 25 in. long and is carried down to a blunt point on straight lines. The needle is operated by means of a hand wheel on the main floor, the wheel-stand also supporting a pressure gauge connecting with the nozzle and the two pipes connecting the two sides of the nozzle body with the balancing chamber of the needle. Each nozzle throws a jet $7\frac{3}{8}$ in. in diameter at full opening. Part of the nozzle tips are of cast steel. Some cast iron tips have, however, been supplied, and it is expected that they will wear as satisfactorily as the steel ones.

Each of the revolving elements of the wheel is 9 ft. 8 in. in diameter and consists of a cast-steel rim to which are bolted 18 bronze buckets. These buckets are $27\frac{1}{2}$ in. wide and are not radically different in form from modern buckets used elsewhere on the Pacific Coast, being in general of an ellipsoidal shape with a straight front wall and a dividing wedge that dips down toward the front of the bucket. The housings of the wheels are of cast-iron with graceful lines, and where the shaft enters are fitted with compound baffle plates or water guards to prevent water escaping from the housing. The sides of the housing have extensions into the wheel pit of removable steel plates, which protect the concrete walls against the impact of the discharging water.

The mechanical and hydraulic design of these wheels was carefully checked by the engineers of the Edison Electric Co., before the manufacturers were allowed to proceed with their construction. The combined moment of inertia of the revolving element in the two water wheels and generators of each unit is $WR^2=1,800,000$ lb.-ft.², by means of

which regulation at 100 per cent. load variations is obtained within less than 8 per cent. when the units are carrying 50 per cent. overload and within less than $5\frac{1}{2}$ per cent. variation of speed when running at normal load. The efficiency guarantee requires that the water wheel proper shall develop an efficiency at rated loads of $82\frac{1}{2}$ per cent., which guarantee is to be substantiated by tests conducted by the company. For sudden changes of load, amounting to 25 per cent., 50 per cent. and 100 per cent. it is guaranteed that the speed variations will not exceed 1.7 per cent., 3.5 per cent. and 7.8 per cent. respectively.

There are two exciter units, each being of the two bearing type, with an impulse water wheel on one end and a heavy fly-wheel designed to give the units close regulation on the other end of the shaft. The exciter wheels are operated from stationary needle nozzles, the needles being of the same straight form used on the main wheels.



Plan of No. 1 Power House.

Regulation is obtained by governors which operate stream deflectors that are pulled up into the stream from below as the load on the unit decreases, thus deflecting a part or all of the stream into the tail-race. The exciter wheels are of a construction similar to the large wheels, having 20 bronze buckets $9\frac{3}{8}$ in. wide bolted to the rim of the runner.

Governors.—Each turbine with its respective governor forms an independent unit. Although the available operating water pressure of 370 lb. from the force main is ample to operate governors, it was preferred to substitute oil governors. The governors are not fed from a central system, but each is absolutely self-contained. The oil pressure is 125 lb.

Special attention was paid to the safe operation of the units, avoiding from the beginning any tendency to run away. For this purpose the arrangement of the generator, as well as the exciter governor was made in such a manner that the jets will be automatically deflected from the buckets whenever the oil pressure in the governor should fail.

The weight of the two deflecting nozzles for each unit is partly carried by a hydraulic balancing piston placed midway between the nozzles, which receives water pressure directly from the force main. The governor arm connects by means of a link to a common rock shaft, which in turn ac-

tuates the two nozzles by means of rocker arms. These shafts are below the main floor and are accessible through a longitudinal alley or tunnel 5 ft. wide, and having a clear head room of 6 ft. 9 in. The governors are driven by a Morse silent-running chain driven from their respective wheel shafts.

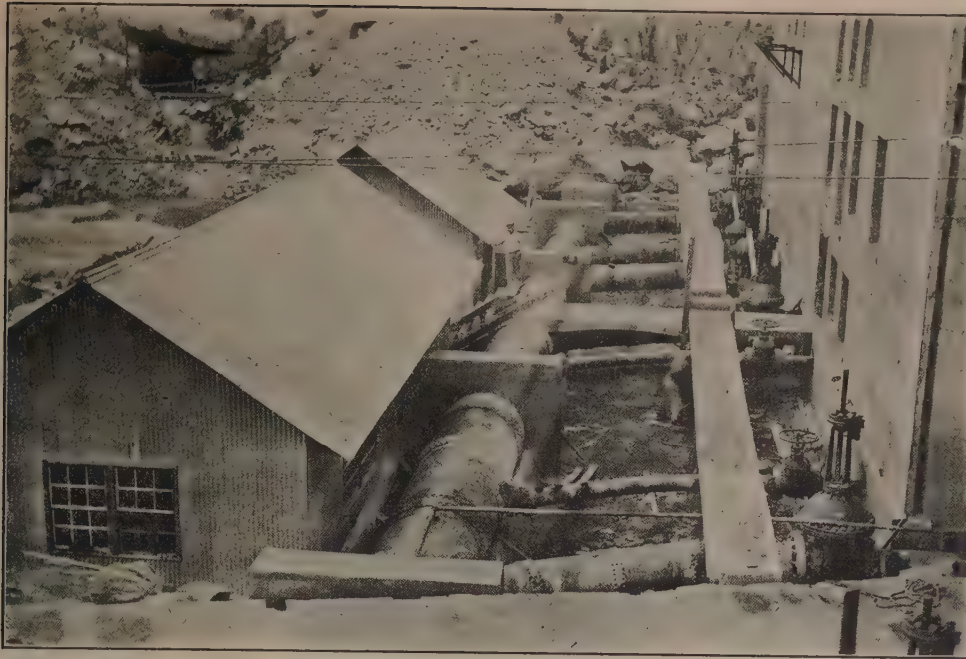
The main casing contains the main operating cylinder with piston and mechanical hand-regulating device. The oil pump is attached to the casing and immersed in the oil reservoir. It is of the rotary type. The main pump shaft also carries the bevel gear which drives the fly balls operating the pilot valve over the regulating lever. The pilot valve is self-contained between opposing pressures, and any reaction upon the fly balls is eliminated. It is evident that this is a principal condition for exact regulation. The pilot valve distributes the oil pressure in the regulating cylinder. The motion of the regulating

piston is reversely transmitted to the regulating valve by means of a combined compensation. The leverage of this compensation is adjustable, so that the governor may be set to any change of speed between no load and full load, from 16 per cent. to absolutely constant speed.

The governors are equipped with four regulating devices which can be used at any time: 1. Mechanical hand regulation (without oil pressure). 2. Automatic regulation with fly balls. 3. Hand regulation with oil pressure (fly balls disconnected by a clutch coupling inserted between pump shaft and fly ball shaft). 4. Hand regulation with oil pressure and electric motor operated from the switchboard. (Synchronizing attachment.)

The exciter governors are of similar design, except that they are not provided for electric hand regulation. All the water wheel equipment mentioned above was supplied by the Allis-Chalmers Company.

The Lombard Governor Co. has furnished for the plant one of its type N governors for operating one of the main units and a type Q governor for one of the exciters. The governors are of the vertical oil pressure type and the order includes the necessary reservoirs, pumps, and similar equipment. The Edison Electric Co. has used Lombard governors in its other hydro-electric plants and is desirous of determining the relative

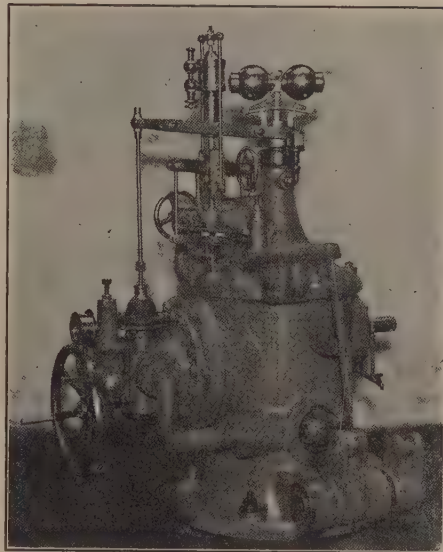


Pressure Header and Branch Piping at No. 1 Power House.

performance of the two types of governors in the new plant.

Tailrace.—Another feature of the water-wheel installation deserves mention on account of its novelty. As already mentioned, the regulation of the wheels is effected by a governor which deflects the jets of the two nozzles. The needles are adjusted by hand and are usually set to that maximum size of jet which will be sufficient to develop the maximum peak loads expected for that period of setting of the needles. In other words, there is always a maximum amount of water leaving the nozzles. The governor adjusts the deflecting nozzles in such a way that only as much water is directed upon the buckets as is needed for the load for the time being. The balance discharges below the buckets into the tailrace. Each jet has a maximum diameter of $7\frac{3}{8}$ in. and leaves the nozzle tip at a velocity exceeding 225 ft. per second. It was necessary to provide means of receiving this tremendous power and deflecting the jet into the tailrace in such a way that its impact would not be detrimental to the structure against which it is directed.

The arrangement designed consists of a pair of heavy deflector plates onto which the jet is diverted. These plates are curved as shown in the elevation of the power house, their design being such as to turn the water through two right angles before it is allowed to pass into the tail race, thus reducing the force of the water so that it can do no damage. The upper of these plates consists of a channel heavily ribbed and bolted to the concrete foundation. The channel at its upper end is slightly more inclined than the deflected jet. Thus the jet strikes the bottom of the channel at a small angle, and therefore tends to spread and fill the section. The channel gradually widens and the jet is consequently offered a larger resistance area. The lower part of the channel is curved and at its end the jet discharges almost perpendicularly downward. The bottom plate is S shaped, its upper end being flush with the bottom of the wheel pit, the lower end practically level. The jet strikes the bottom plate almost in the turn of the S and under a small angle. Thus the jet is again forced to spread and follow the base of the bottom plate. The deflectors are lined with removable steel plates wherever the surfaces are exposed to the flow of the deflected jet, being held in position by lag screws. The plates are 7 ft. wide and the



Allis-Chalmers Exciter Governor.

lower one projects out into the tailrace 8 ft.

The wheel races are lined with steel on both at 430 r.p.m. and having ordinary self-adjusting

sides and fitted with steel back plates just back of the nozzle tips to keep the splash water out of the shaft alley.

The tailrace is 29 ft. wide and extends the length of the power house. It is fitted with two 25-ft. steel plate weirs, the lower weir at the end of the tail race being 4 ft. below the level of the upper weir, which has its crest 13 ft. 6 in. below the line of the nozzles.

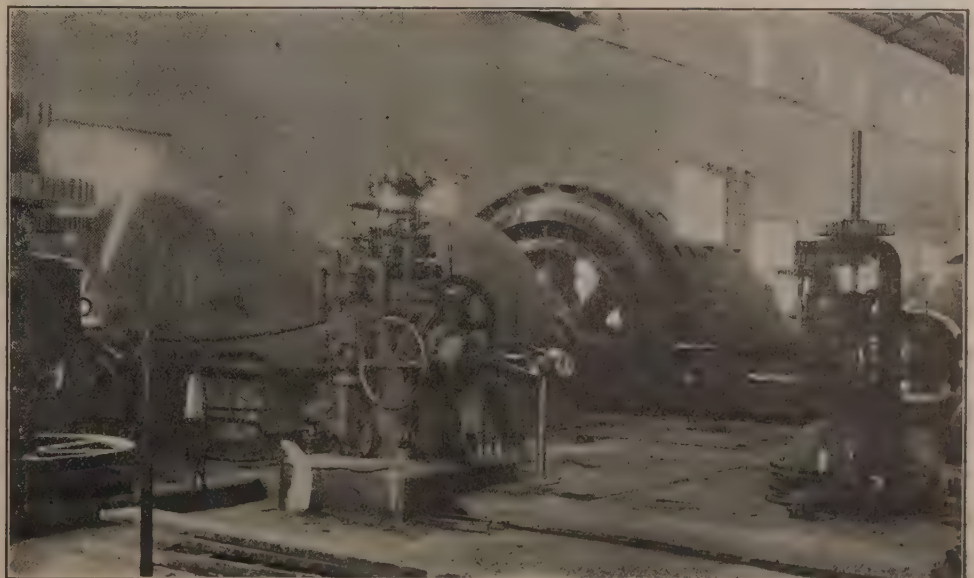
The water wheel branch pipes enter the power house at the south side and after passing across the transformer rooms and before joining the nozzle bases connect to 28-in. cast-steel gate valves. These valves are of a special design and are each operated from the control switchboard by a 1.2-h.p. 120-volt Allis-Chalmers motor. These motors are mounted vertically and operate at 460 r.p.m. It requires $7\frac{1}{2}$ min. to open or close a valve by means of the motor. All of the gate valves are equipped with 4-in. by-passes.

In the machine room of the power house is installed a Dibble reservoir gate equipped with an indicating dial and a registering chart for measuring the water in the forebay.

Capacity of the Plant.—The normal rated capacity of the Kern River No. 1 power plant is 20,000 kw., or 26,667 electrical horse power. The machinery is all tested to operate under 50 per cent. overload for peak load service, thus making the ultimate capacity of the installation 30,000 kw., or 40,000 electrical horse power.

Generators and Electrical Equipment.—The main generators are of the standard General Electric A. T. B. type, form S, and have a rated capacity of 50,000 kw. The stationary armature is bar wound for 2,300 volts 3-phase 50-cycles. The main units are each carried on two 16x48-in. babbitted bearings, each fitted with six oil rings for flooding them with oil from the cellars contained in their pedestals. In the pedestals the oil is cooled by means of water coils built into them. Each bearing also has in its lower portion a number of small openings which are connected to a triplex motor-driven pump capable of circulating the lubricating oil under a pressure of 1,000 lb. to the square inch. The generator shaft is flared out at each end to form a flange to which is bolted the wheel disc. The shaft is also enlarged at the center to carry the cast-steel pole rim and spider. This latter is a single casting weighing 26 tons. The pole pieces are wedged to the exterior of this rim.

The exciter units are standard 225 kw. direct current machines generating at 125 volts, running



Unit No. 2, Governor and Top of Motor-Operated Gate Valve.

bearings. Sufficient space has been left between the two exciters to permit the installation of a large induction motor at some future time should it be found necessary. This motor would be designed for good speed regulation and arranged so that it could be connected by means of a pair of clutches to either of the exciters.

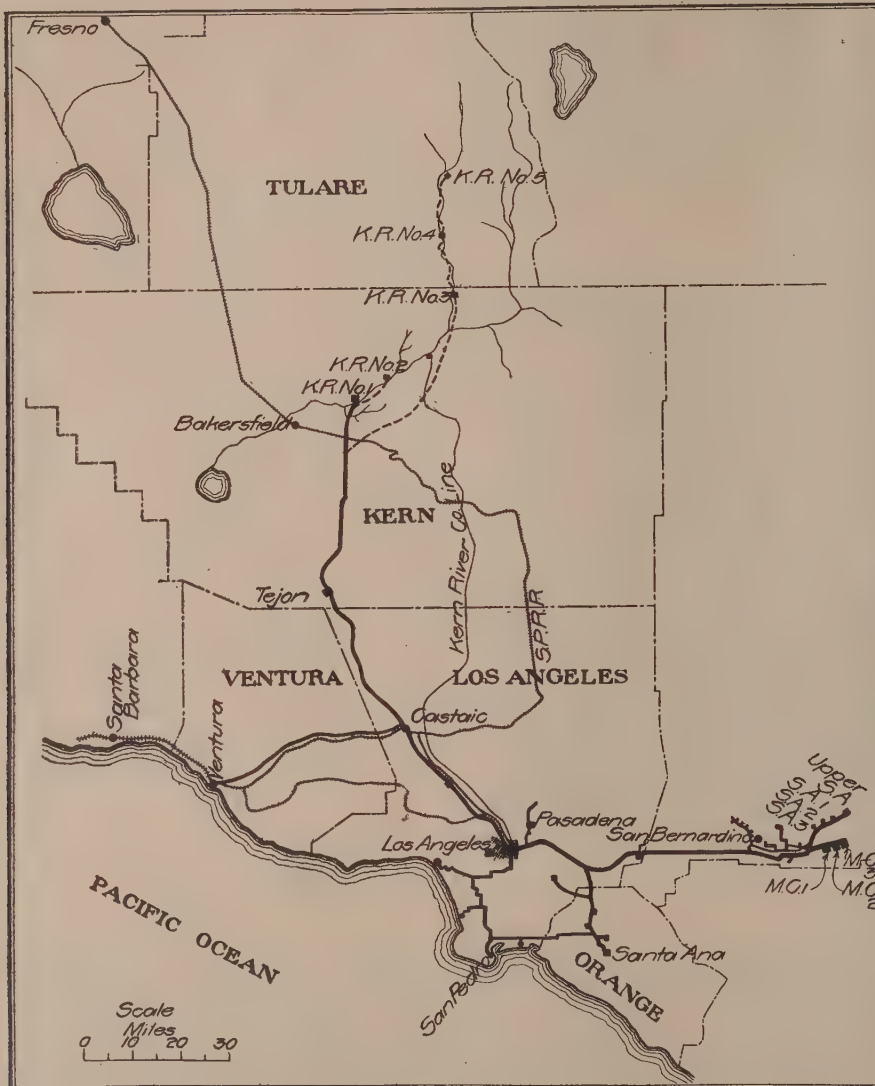
The station contains thirteen 50-cycle, 1,667 kw. oil-filled shell-type oil-circulated transformers in boiler iron cases. These transformers are grouped in 4 banks of 3 each with 1 pair to receive energy at 2,300 volts delta from the generators and to supply it to the line at 75,000 volts Y. Taps are also provided for the intermediate voltages of 56,250 and 37,500. These transformers instead of having internal water cooling coils are so built that when the oil is supplied to them under

are at present installed. From these cooling coils the oil returns to the pressure line which supplies the transformers. As the system is under pressure from the time the oil enters the pump, any leakage will be outward and there will be no possibility of the water leaking into the oil, as is the case where the water coils under pressure are placed in oil filled transformers. Another advantage of this system is that the cost of installation is somewhat less than for a similar installation using water cooling. Water for the cooling section is by-passed from one or both of the exciter tail-races into a flume built across the top of the coolers.

The generator leads pass through ducts under the station floor to the generator switches and thence to the low tension side of the transformer

taining no additional apparatus except lightning arresters.

The control switchboard is mounted on a gallery overlooking the machine room. It is built of black slate and is a combination bench and panel board consisting of nine divisions. One of the panels controls the station auxiliaries, two of them the exciter circuits, four the generator units, one the auxiliary feeder and the remaining panel is at present left blank. These panels are equipped with the necessary meters and switches. The bench of the switchboard has controlling switches with red and green signal lamps for each



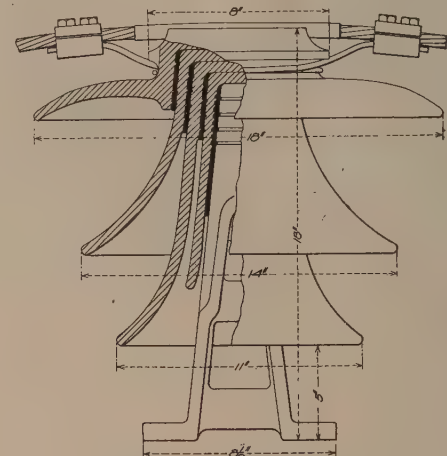
Map Showing Power Plants and Transmission Lines.

a slight pressure it will automatically distribute itself throughout their windings and return by gravity to the waste pipe. The piping and connections for this circulation are placed in the basement of the power house in a tunnel 7 ft. 9 in. wide and 11 ft. high, extending the length of the building.

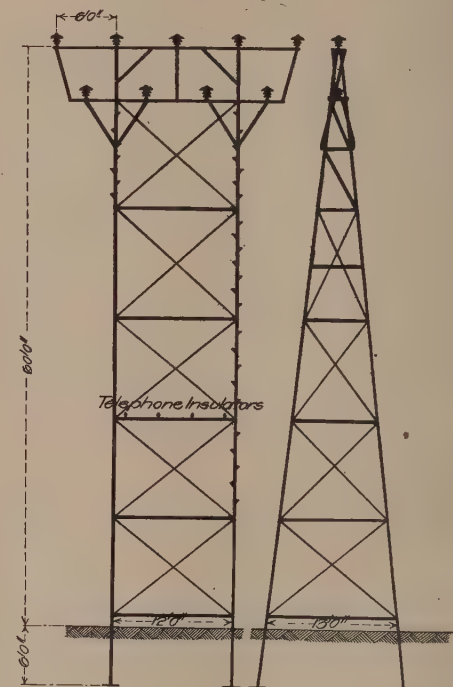
The oil coming from the transformers enters a receiving drum from which it is drawn by two 5-in. centrifugal pumps, motor-driven by 15-h.p. variable-speed shunt-wound direct-current motors. Either pump can supply the entire equipment of transformers in an emergency. These pumps force the oil through a set of boiler tube coolers, set over the tail-race and consisting of a series of 2-in. pipes, 10 ft. long, made up in four sections containing 1,008 tubes and having a total area of 4,500 sq. ft. Only two of these sections

bank. The station is equipped in such a manner that in case of necessity any generator can be transferred to any single transformer bank or in case of absolute necessity run in multiples with some other generator on a single transformer bank, or if desired the entire station can be tied together and operated as a single unit.

The transformer banks connect on their high-tension sides to knife blade switches to a single bus bar from which the two outgoing transmission circuits are tapped off. The 2,300 volt oil switches are installed in concrete cells with concrete barrier walls and tops. The disconnecting switches for them are also separated by barrier walls where possible. The 75,000 volt oil switches are not only installed in concrete cells in accordance with standard practice but are each of them enclosed in a separate concrete room con-



Insulator for 60,000-Volt Line.



Transmission Line Tower.

of the four generators, and control switches are also provided for the feeder switches, the bus sections and the outgoing line switches.

All the electrical equipment in the station including generators, exciters, transformers, oil switches and switchboards were supplied by the General Electric Co.

The high tension wiring is run in 4-ft. square ducts throughout. The lightning arresters are of the General Electric Co.'s multiplex type, consisting of alternate carbon spark gaps and resistance. They are mounted in concrete wall cells and are so completely isolated from each other by the intervening main line ducts that an arc starting on any single arrester could not by any possibility be transferred to any second bank. The leads after passing the choke coils and taps for the lightning arresters pass out of the south

wall of the building through rectangular openings located immediately below the eaves. From the eaves of the building, the leads converge onto the first tower of the transmission line.

The transmission voltage now used is 60,000, but 75,000 volts will be substituted later. The transmission line, 117 miles long, is carried on galvanized steel towers ranging from 30 to 60 ft. high. They are made of galvanized angles, bolted with galvanized bolts and held in shape by means of tension rods. All portions of the

obtain rights-of-way across private property and the Sierra forest reserve which required more than one year. The final location survey began in the summer of 1902, and construction was commenced near the close of that year. Continuous construction work was prosecuted vigorously during 1903, but in 1904 was slackened up owing to the fact that the company had two other power plants to construct at that time. During that year, however, the work was prosecuted on some of the longest tunnels, there being about four

under 40-ft. head to McCormick reaction turbines each operating one 150-kw., 2,300 volt generator. This plant furnished all the energy required while the work was in progress and was only abandoned after the completion of the main plant. It frequently and for long periods operated at 50 per cent. overload. From the construction plant, power was transmitted at 10,000 volts to all parts of the work over a temporary transmission line, the power being used not only for the construction work, but for lighting both in the tunnels and in the camp quarters occupied by the men.

For driving the tunnels compressed air was generated by electrical power, transmitted from the construction plant, and was piped into the various tunnels for operating the pneumatic drills. The ventilating blowers for supplying fresh air at the face of the tunnel and for removing the fumes after a blast were also operated by electric motors. In the construction of the diverting a dam a complete system of cableways designed by the company's engineers was installed by means of which material was transported and placed in position in the dam. In the construction of the power house the handling of materials as well as the crushing of rock and mixing of concrete was carried on by means of equipment operated by electric motors. The hoisting engines for the aerial tramways used at Camp No. 1 and other camps for hoisting material to the tunnels were also operated by electric motors.

The station was placed in operation under the direction of Mr. H. H. Sinclair, one of the vice-presidents of the company. Water was first turned into the tunnels on May 11th, when it



Los Angeles No. 3 Receiving Station.

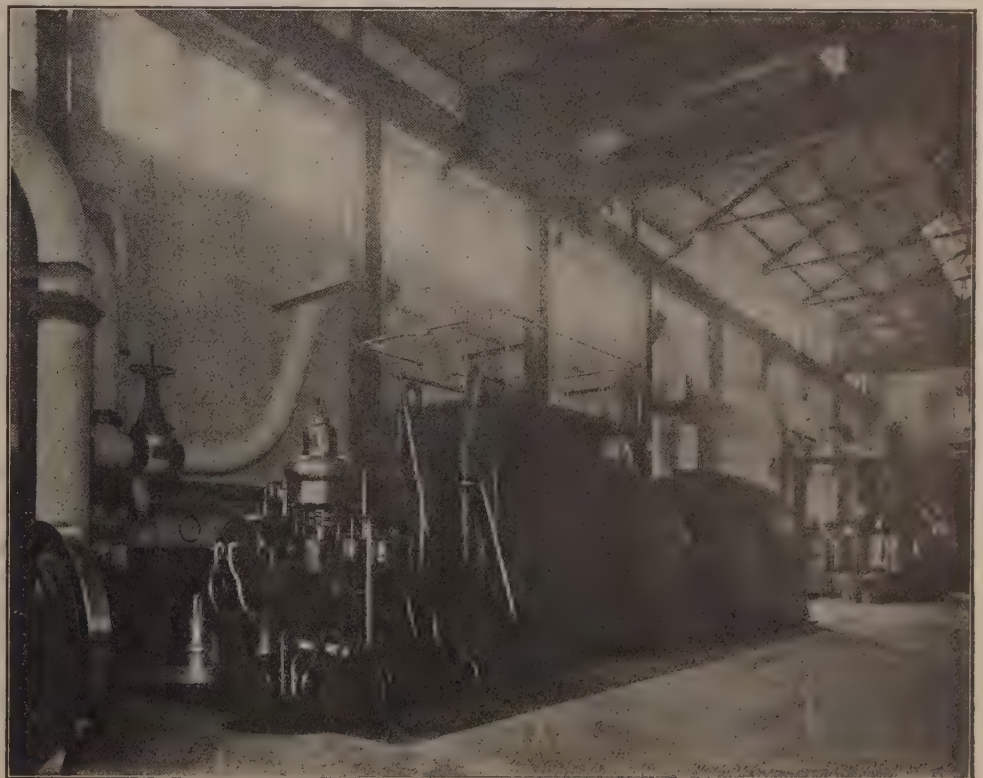
tower are figured to be safe under a wind pressure of 30 lb. per square foot on the tower and on the wire of a 700-ft. span. The towers will also withstand absolute failure of any single wire even though none of the resulting strain is transmitted to adjacent wires. They were furnished by the U. S. Wind Engine & Pump Co., Batavia, Ill.

The transmission line is designed to consist of 3 circuits with the wiring spaced symmetrically on 6-ft. centers. The wire is 7-strand, 4/0 hard drawn copper having an elastic limit exceeding 35,000 lb., and an ultimate strength of 62,400 lb. It was furnished by J. A. Roebling's Sons Co., National Conduit & Cable Co., and the American Electrical Works. About two and a half million pounds of cable were used on the line.

The insulators used on the transmission line are the largest yet made for commercial transmission purposes. They are 18 in. high and 8 in. in diameter at the grooved top. The top section is 18 in. in diameter and the two lower petticoats are respectively 14 in. and 11 in. in diameter. The specifications for the insulators call for a guarantee of a 100,000-volt test from the groove to the pin for half an hour under a precipitation of 1 in. in 5 min. at an angle of 30 deg. from the vertical. The assembled insulator was required to stand under a wet test a potential of 150,000 volts for 30 sec., and the separate parts are guaranteed to stand a voltage 25 per cent. in excess of the normal proportion of over voltage test.

A telephone circuit is carried the entire length of the transmission line, being supported on the towers about 20 ft. above the ground. Between towers the wires are held up by wooden poles, 2 poles being necessary between towers for an average 700-ft. span. Switching stations are located on the transmission line at Tejon, Castaic and San Fernando, the latter two also containing transformer sub-stations.

Construction.—The first preliminary survey for location of the plant was made in the Spring of 1901. After that time it became necessary to



Westinghouse-Parsons 7,500 Kw. Turbo-Alternator in Receiving Station.

tunnel faces kept in operation the whole year. In the early part of 1905 work was again resumed with vigor and prosecuted until finally completed about May 10, 1907.

A construction plant generating 300 kw. at normal capacity was installed for furnishing the power used in driving tunnels, mixing concrete, transporting material and similar construction work. This plant was located at Frenchtown, or Camp 5, power being developed by means of a flume about 800 ft. in length which supplies water

was wasted out at the Starr Creek flume. On the following day about 300 miner's inches of water were turned into the entire tunnel, the first water being carried through the pressure mains and sluiced out of the ends of the power house header into the river. On May 13, full pressure, 380 lb., was placed on the plant and the first unit and one of the exciter units started up. After a few days of necessary drying out on May 19th, power was first put on the line from the station end and 2,500 kw. transmitted to Los Angeles. The first

unit has been operating continuously since that date, and the other three units will be started up as soon as their installation is completed, some of the machinery having been delayed in transit.

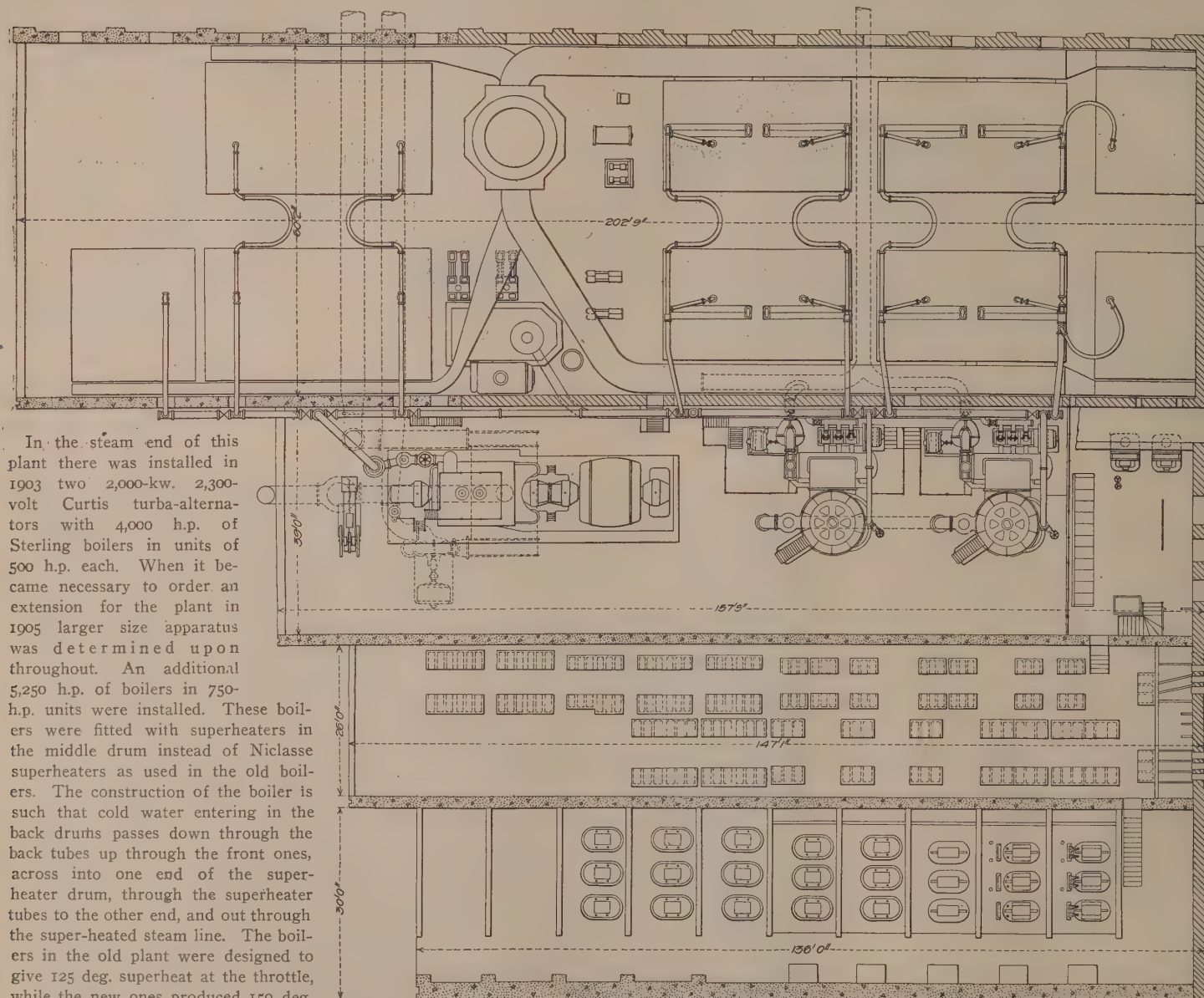
Los Angeles Receiving Station.—The transmission lines from the new plant terminate at the steam and transformer station known as Los Angeles No. 3, which receives, transforms and distributes to the local sub-stations power received from the company's water power plants at Santa Ana River, Mill Creek, Lytle Creek and Kern River and also contains a large steam auxiliary plant to supplement the water-generated power.

Steam from the exhaust end of the turbine passes to the atmosphere during warming up through an automatic release valve. After the machine is up to speed, 750 r. p. m., the steam is condensed into a 24,000-sq.-ft. condenser and the water of condensation returns to the hotwell by a 2-stage motor-driven centrifugal pump. The vacuum space is cleared of entrained air by means of a steam-driven dry vacuum pump. Forty-nine second feet of condensing water are forced through the condenser by means of a 30-in. volute centrifugal pump direct connected to a 450-h.p. induction motor, driven from the 2,300-volt main.

Circulating water leaving the condenser passes

galvanized iron with wooden sliding gates. Strips 18-in. wide of galvanized iron mesh screen are placed at 3-ft. intervals through the depth of the tower. The reservoir is of concrete 6 ft. deep and 12 ft. wider than the tower. Water passes from it into the concrete suction pipes through close-set grizzlies. Its flow can be shut off when necessary by a 38-in. iron motor-driven gate placed in the engine room basement.

The Westinghouse turbo-alternator unit was put in service in October, 1906, and has been run ever since without any shut-down due to the turbine and without any serious shut-down whatever. The preliminary acceptance test gave re-



Plan of Los Angeles No. 3 Receiving Station.

In the steam end of this plant there was installed in 1903 two 2,000-kw. 2,300-volt Curtis turbo-alternators with 4,000 h.p. of Sterling boilers in units of 500 h.p. each. When it became necessary to order an extension for the plant in 1905 larger size apparatus was determined upon throughout. An additional 5,250 h.p. of boilers in 750-h.p. units were installed. These boilers were fitted with superheaters in the middle drum instead of Niclasse superheaters as used in the old boilers. The construction of the boiler is such that cold water entering in the back drums passes down through the back tubes up through the front ones, across into one end of the superheater drum, through the superheater tubes to the other end, and out through the super-heated steam line. The boilers in the old plant were designed to give 125 deg. superheat at the throttle, while the new ones produced 150 deg. The new boilers have heavy drums and are fitted in every way to carry 175 lb. pressure, although the plant is now operated with 165 lb. at the boiler.

The turbine installation in the new plant consists of a single 6,000 kw. Westinghouse-Parsons turbo alternator with Worthington condensing equipment. The steam end is of the Westinghouse standard construction receiving steam through an intermittent valve. This steam before reaching the machine passes through a separator, an automatic butterfly valve and a hand-operated throttle valve. The unit is 4-stage single-flow and is operated at $27\frac{1}{2}$ to 28-in. vacuum. Thus far loads up to 10,000 kw. have been carried on the machine without any indication of its maximum load being approached. The by-pass throttle does not open until 9,000-kw. load is reached under normal steam and vacuum conditions.

beneath the boiler room in a steel lined concrete duct to the edge of the cooling tower where it rises through a steel pipe to the top of the tower. The new portion of the tower installed for the Westinghouse unit is 73x150 ft. in floor plan and the water has a clear fall of 27 ft. This gives a tower area of 6,100 cu. ft. per second foot of water and with a humidity of 58 per cent, and a wind velocity of 6 miles per hour the water temperature is reduced from 102 deg. to 85 deg. Fahr. The tower framing consists of 4x4-in. posts, 2x4-in. intermediates, 1x2-in. horizontals and 1x3-in. bracing. The main flume is carried on 6x6-in. posts and is itself built of 1½-in. redwood. The distribution troughs are galvanized iron of rectangular cross section with round holes punched in their bottoms. Their headers are also

suits materially better than the manufacturers' guarantee.

Extent of the Company's System.—In addition to the Kern River No. 1 Plant the Edison Electric Co., controls sites for four other plants on the Kern River, all of them above the plant just completed. They cover the entire length of the river 160 miles from the mouth of the canyon to the head works with the exception of the plant of the Power, Transit & Light Co., at the mouth, and the Kern River Company's plant about 30 miles above. The four additional plants will have a total capacity of 46,600 kw., and will be developed as the demand for power arises. The next plant to be constructed will be Kern River No. 2, the power house for which will be located immediately above the intake of the No. 1 plant.

Its diversion works will be 15 miles above, just below the Kern River Company's station. With the 317-ft. net head which will be available, this plant will develop a total of 11,600 h. p. with 400 second feet of water. Some work has already been done on this plant and the construction will soon be pushed ahead actively. In addition to the Kern River power locations which the company owns in entirety, it has a 2/3 interest in five excellent power sites on the Kings River, where 95,000 kw. can be developed.

The company is now operating 7 plants, including the one described in this article. The 6 earlier plants have a total capacity of 8,700 kw., the steam generating plant a capacity of 14,075 kw.; and it is expected that the Kern River plant will be able to deliver in Los Angeles a maximum of 23,000 kw. Thus far the company's maximum peak load has been about 20,000 kw. Judging by past experience it is probable that the new power will be contracted for as fast as it is available. The company now supplies current for light and power to some 16 cities comprising a population of 418,500. Its transmission lines traverse six counties.

The company is incorporated under the laws of Wyoming and has \$11,200,000 of its capital stock issued, consisting of \$4,000,000 preferred and \$7,200,000 common stock. The outstanding bonds

the drawings and much of the data which have made this article possible.

The Tarring of Highways.

The increased attention which is being devoted in the United States to allaying the dust nuisance on our highways and to decreasing their disintegration under motor traffic makes a report which has recently appeared in the "Annales des Ponts et Chaussées," by the secretary of a commission appointed by the French Minister of Public Works to consider this subject, of much interest.

The report classifies the various processes which have been employed, disregarding sprinkling with pure water, into four classes: 1, Surface tarring, either hot or cold; 2, treatment with petroleum oil or similar processes; 3, sprinkling with water to which various substances have been added; 4, several processes

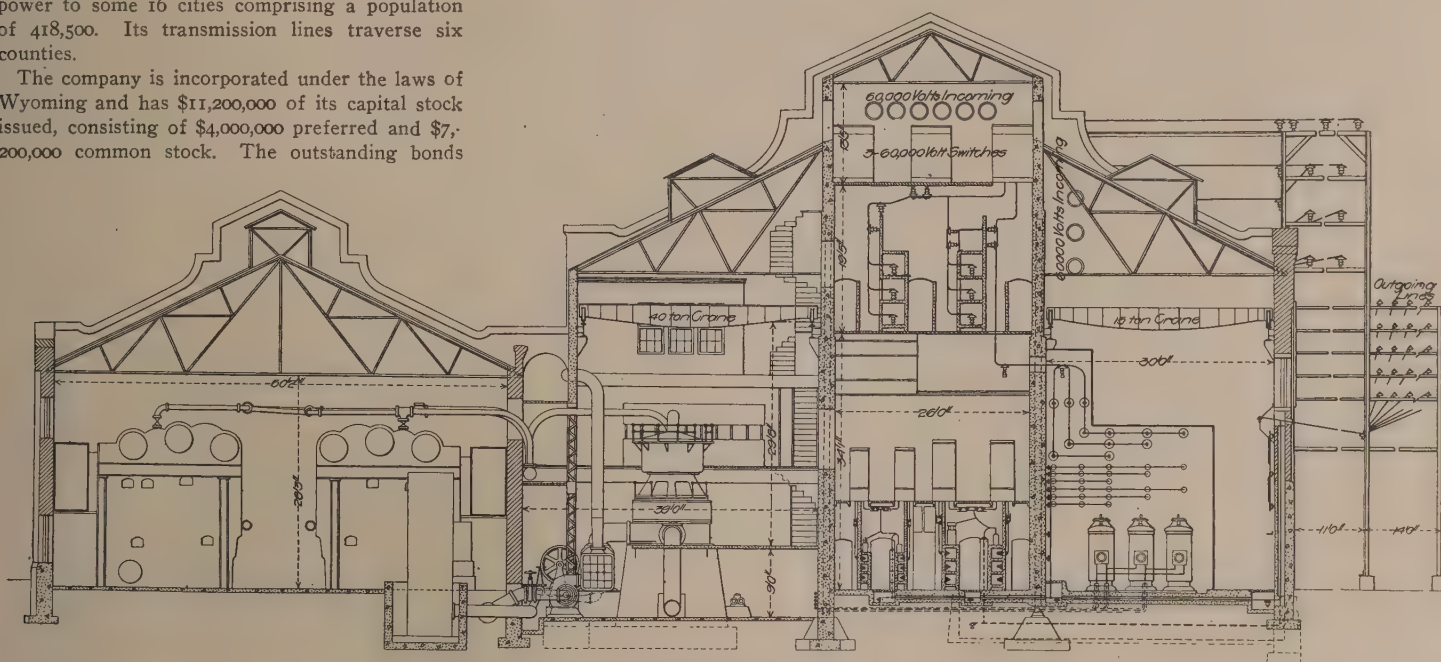
it covers the entire surface without lack of continuity.

5. To let the tar dry out sufficiently, so that the wheels of vehicles will not pick it up nor skin off the coating.

From the information obtained through inquiries of various engineers by the Commission the report draws certain conclusions in regard to work done in summer as compared with that done in autumn and winter.

Summer Work.—There is a complete agreement that tarring, when done in the summer, is always satisfactory. Dust is suppressed, or at least notably diminished, and damage to the roadway is largely checked. These results are dependent upon the nature and the intensity of the traffic, the exposure of the road, the quality of the material of which it is constructed, as well as the manner of application, whether hot or cold.

The protection of the roadway upon routes trav-



Section Through Los Angeles No. 3 Receiving Station of the Edison Electric Co.

and debentures of the company amount to \$10,895,000. The officers of the company are: President, John B. Miller, Pasadena; Vice-presidents, Henry Fisher, Redlands, Wm. R. Staats, Los Angeles, H. H. Sinclair, Pasadena, John W. Edminson, Los Angeles; Secretary, R. H. Ballard, Los Angeles; Treasurer, W. L. Percey, Pasadena; General Manager, A. L. Selig, Los Angeles.

The construction of the Kern River No. 1 Power Plant was prosecuted under the general supervision of Mr. H. H. Sinclair, vice-president of the company who originally located the power site on the Kern River and on most of the other streams whose power supplies are controlled by the company. The hydraulic features of the Kern River work including the dams, gravity tunnels, pressure tunnels and many of the details of the water wheel equipment were designed under the supervision of Mr. F. C. Finkle, chief hydraulic engineer and now consulting engineer for the company. Mr. F. E. Miller, as superintendent of power development, had charge of, and at times direct supervision over the construction work. The electrical details were looked after by Mr. Ralph Bennett, and Mr. R. J. C. Wood. Mr. G. E. Decker represented the company in the installation of the machinery. Mr. John Taylor formerly chief operator at the Santa Ana No. 1 plant has been placed in charge of the operation of the new plant. To these gentlemen the writer is indebted for many courtesies, for the furnishing of

which cannot be included in the preceding classes.

Tarring.—After a historical note upon the subject, showing that the tarring of roads only reached any extent in 1902, the author describes the two methods which are in use to-day, the one cold, by thinning the tar with 10 per cent. of heavy or dead oil so that it can be absorbed, and the other by applying the tar hot. It is shown that in order to obtain satisfactory results it is necessary to allow the tar to soak into the road as long as possible before admitting traffic, and that if the absorption is not complete a light application of sand, or of the dust which has been originally swept from the road should be applied.

The conditions to be realized in order to meet with success are as follows:

1. To operate upon a road recently put in order, well rounded and sufficiently drained. Tar lasts much less time upon a flat surface, while from one which is moist at the time of spreading it scales off and disappears rapidly.
2. To carefully clean the street from the dust and filth which cover it and to expose the mosaic of stone in a way that will permit the layer of tar to penetrate into the road and, so to speak, anchor itself there thoroughly.
3. To operate only in dry weather and, if possible, only in hot weather.
4. To spread the tar in such a manner that

elled by motor vehicles is particularly striking.

Autumn and Winter Work.—Experimenters are of different opinions in regard to tarring done in autumn and winter. All agree that it lasts well upon rounded streets of good exposure, subjected to not too heavy traffic. As one or the other of these conditions is not fulfilled, the superficial coating of tar disappears at the end of a longer or shorter time, and it is rare that it lasts to the end of winter, at least on the crown of the road. Very often, if traffic is heavy, it has disappeared at the beginning of winter.

The tar, moreover, in the act of disappearing during bad weather, produces a very disagreeable mud, and one which is much more abundant than that from roads which have not been tarred. The majority of experimenters are agreed that with roads carrying a heavy and active traffic, as much as 600 to 700 collars, this result is, without doubt, to be expected. According to a minority, on the contrary, but who include the highest authorities, the diminution of the mud is quite sensible in winter, even on moist sections of road and those subjected to a heavy circulation.

These differences seem to pertain to the nature of the macadam and to the material of which it is composed. It is difficult to discover, from the answers to the questions, why this is so, as the replies do not give the details in

regard to the manner and care with which the tarring has been carried out.

It is beyond doubt that as long as the coating of tar lasts the roadway is guaranteed to a great extent against disintegration, but it must be remembered that the coating is a superficial one and not entirely continuous. The stone pierces it in many places and the exposed particles are worn down under traffic. The coating, on account of its plasticity, again covers these and other projections appear. There is always a certain wearing away of the stone by percussion or lateral friction, notwithstanding the bituminous material which supports them. It appears, then, that the tarred road is not entirely shielded from disintegration. If the coating of tar resolves itself into mud this mud retains water more easily, is more mobile and the road goes to pieces more readily. The general impression of all experimenters is, however, that tarring prolongs the life of the road; to what degree this takes place the observers are not agreed and do not dare give any definite value.

Tar Employed Per Square Yard.—This will depend upon the porosity of the road and the judgment of the operator. The first essential condition is that the tar shall cover the surface entirely. Upon a very absorbent surface, as one composed of dry silicious rocks thoroughly compacted, one would necessarily employ more tar than on a smooth and less permeable roadway of porphyry. In the same way a street which has been tarred the year before calls for less than one which is being treated for the first time. The minimum quantity is, then, a function of the state of the road, but in any case not less than 2 lbs. per square yard should be used. This amount can be increased according to the judgment of the operator. In the experiments made in France it has varied between 1.6 and 1.8 to 8.0 lbs. per square yard, with a mean in the neighborhood of 3.0 lbs. Experience has shown that it is advisable to avoid too thick a coat, which might prove slippery and provoke the formation of mud in winter. It seems that 4.0 lb. per square yard should be regarded as a maximum, beyond which it is not advisable to go. This means something less than one-half of a gallon.

Penetration.—The penetration of the tar into the surface should be carefully looked into to determine that the coating is well anchored. In well-conducted work the penetration should reach easily 1.25 to 1.6 in.

Effect of Temperature and Grade.—Frost does not seem to have any injurious effects upon tarred roads, in spite of the fears that have been entertained in regard to it. Excessive heat may soften it and even render it slippery. This is, however, rare, and is generally due to poor execution of the work and insufficient penetration.

One generally hesitates to tar a road having a grade of over 3 per cent., and a recent experiment at Aix-les-Bains on a 5 per cent. grade seems to demonstrate this.

Effect of Water.—Summer rain is favorable to tarred roads, as it cleans them, drying rapidly, and does not contribute to their disintegration. The washing of such streets with quantities of water, as in the manner carried out in cities, has the same effect. It is necessary, however, not to abuse this custom, especially on streets of heavy traffic, for the enemy of tar is persistent humidity.

Cost.—The cost depends on: 1, the quantity of material employed; 2, the price of this material; 3, the system of spreading adopted and the capacity of the plant.

An application of 3 lbs. of tar at a price of \$10 per ton should not cost for material more than 1.3 to 1.5 cents per square yard. Labor for heating, spreading and sanding costs in

France in the neighborhood of 1 cent per square yard. The Commission considers that the entire cost of tarring in France is, in the mean, between 2 and 3 cents per square yard, this, of course, for the first treatment. Subsequent treatment will cost less.

Methods of Treatment.—Tarring with hot tar, without any addition, is the method most frequently employed. A mixture of ordinary tar with 10 per cent. of dead oil has been practiced upon a considerable scale in various departments, especially at Havre, while some experiments have been conducted in Paris and in the Department of the Rhone. As far as can be judged, the two systems are identical in their results in both summer and winter, but in point of view of execution of the work the cold method does away with many inconveniences and the necessity for heating. The apparatus is less costly, the spreading is much facilitated, since no attention must be given to the temperature of the material, while the presence of dead oil has a happy drying effect. As a matter of economy the cost of heating is compensated by the greater cost of the heavy dead oil. Whether one system or another is to be adopted will depend upon local conditions. The use of crude tar without anything to make it more liquid is not to be recommended. It penetrates but a small distance into the roadway, especially in winter, remains upon the surface and dries badly.

Certain patented materials containing special driers, process Rimini, Pulveranto, d'Auch, Lassailly and Vinsonneau, are still in the experimental stage, as are particular methods of application, such as heating the tar after it has been placed upon the surface. More will have to be known of the success of these processes before they will be adopted in America.

Oiling Roads.—California seems to be recognized in the report as initiating the method of laying dust by oiling roads with a suitable oil. As no oil similar to the California petroleum is available abroad, mazout, the residuum from the distillation of Russian petroleum, has been used in France.

The report of the Commission gives few data in regard to the results obtained, but states that the difficulty with the use of this material is the high tax, \$18 per ton, to which it is liable.

Sprinkling with Water Containing Other Materials.—The report considers the sprinkling of roads with solutions of deliquescent salts, and with mixtures of water and oil, such as westrumite and various other patented products. The results with these materials are in any case only temporary and last at the most for fifteen days and do not seem to be favorably regarded.

THE RIO DAS LAGES HYDRO-ELECTRIC STATION of the Rio Janeiro Tramway, Light & Power Co., is being constructed rapidly and before the end of the year it is expected that six generators will be in place. The falls supplying the power are 56 miles from the city, and a concrete dam has been constructed at their crest, which is 115 ft. high and 92 ft. thick at the base. From this reservoir water passes through a series of steel pipes about 6,000 ft. long to distribution receivers immediately above the power house. From the receivers six 36-in. pipes about 1,900 ft. long, are carried down to the six turbines. The receivers are about 900 ft. above the power station and the pipes leading to the turbines are on a steep grade. The total head when the reservoir is full is about 1,030 ft. from the level of the spillway on the dams to the nozzles of the turbines. Each of the six main wheels will develop about 9,000 h.-p., and will drive a three-phase, 50-cycle, 6,000-volt generator. It is proposed to step up the voltage of the current to 80,000 volts for transmission to Rio Janeiro.

Mechanical Equipment of the New City Hall at Newark, N. J.—I.

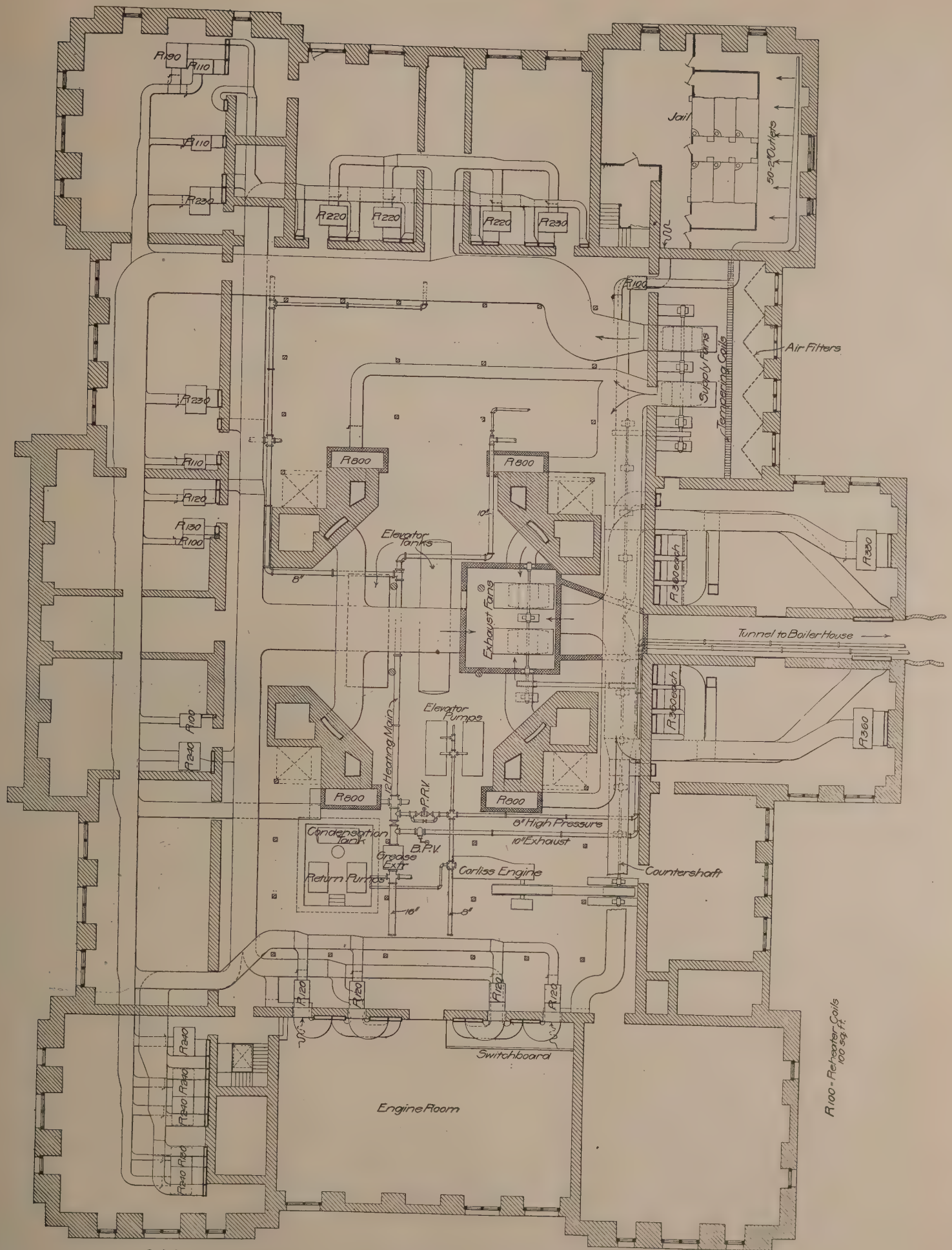
The City of Newark, N. J., has recently occupied an attractive new building for its municipal departments and offices which has a novel interior arrangement and an unusual heating and ventilating equipment. It has four stories and a basement and is surmounted by a central dome rising 135 ft. above street level. The structure is 175x240 ft. in plan and has an 83x153-ft. interior court surrounded by balconies forming the corridors of the various floors. In the center of this court is the structural work supporting the dome and elevator shafts, which has a most pleasing architectural treatment.

Current for lighting and a limited amount of power is purchased from the local public lighting company, but provisions have been made for a complete generating plant if it should be desired in the future. Provision has been made for ample ventilation of all rooms which are to be publicly occupied to any extent and also systems of exhaust from all toilet rooms. The heat and discomfort attendant upon a boiler plant in the basement of the building is avoided by having an independent boiler house at the rear of the grounds, with tunnel for steam and piping connections. This auxiliary building houses, however, only the boilers, the remainder of the mechanical equipment being installed in the sub-basement of the main building.

The general arrangement of the mechanical plant is shown in the accompanying plan of the sub-basement. The greater portion of the equipment is accommodated in the central portion under the interior court, the elevator equipment and exhaust fans occupying the circular portion under the dome, while a number of condensation tanks, pumps and piping, together with the engine which drives the ventilating equipment, are in the westerly portion of this area. The spaces surrounding this central area are for the greater part utilized as store rooms for the city departments, with the exception of that under the easterly wing which is occupied by the tunnel and a large amount of duct work for the fresh air supply system, and 21x44-ft. space adjoining this which contains the air intake and filter chamber, and the fresh air fans. A 35x60-ft. room at the westerly end of the sub-basement is reserved for possible future use as an engine room, and now contains the distribution switchboard for the electric lighting and power service, which has been so arranged that the addition of the necessary switch-board equipment for generating machinery will not be difficult.

The boiler house is 45x65 ft. in size and situated 50 ft. to the rear of the main building. This building has its floor 7 ft. below sidewalk level, and is connected with the main building by a brick tunnel 8 ft. square and 14 ft. under the surface, the tunnel entering slightly below the level of the sub-basement floor, which is 10 ft. below the sidewalk level. At the boiler house end, piping connections are carried up through a vertical shaft which rises to the roof in the corner of this building as a ventilation shaft.

Boilers.—Steam is furnished by three horizontal return tubular boilers in a single setting at one end of the boiler house facing a 35-ft. space in front, about 30 ft. wide, which serves both as firing floor and fuel storage. There is a 4-ft. space at the rear of the settings for access to blow-off connections and dampers, and 12 ft. at one side, provides for blow-off tanks and auxiliaries and also the addition of a fourth boiler unit if future demands for power should require. A convenient drive-way from the street facilitates the handling of coal, wagons being dumped directly through the large doorway at



Sub-basement of New City Hall, Newark, Showing Mechanical Plant and Ventilating System.

the front into the storage space, where fully 100 tons can be stored without restricting the firing floor space. Ashes are elevated to the driveway level for removal in carts by a small hydraulic four-can ash hoist of the sidewalk elevator type, which is operated by the hydraulic elevator system of the main building; the hoist is located just outside the front of the building and rises to the level of the driveway. Although the floor level is depressed some 7 ft. below the sidewalk, it is still above that of sewers in the adjoining streets which facilitates drainage from the floors and from the blow-off tank.

The boilers are 150-h.-p. units with $6\frac{1}{2}$ -ft. shells, 20 ft. in length, containing eighty-four 4-in. tubes and were built by the Coatesville Boiler Works, Coatesville, Pa. They have $\frac{1}{2}$ -in. shells with quadruple riveted double butt strap seams and $\frac{5}{8}$ -in. tube sheets, and were designed for 125 lb. pressure. They are without domes, ample space being provided above the tubes for a low water line and large steam liberation surface, and in this space there is a dry pipe 84 in. in length, 9 in. deep by 8 in. across at the top, which connects with a 6-in. nozzle in the center of the front sheet. Five-inch safety valve nozzles are fitted to the center of the middle sheet of each shell. The boiler setting has 24-in. outside walls and 28-in. division walls and the boilers are supported on roller bearing rests. The settings have flush fronts, and are designed for three passes of the products of combustion, the third pass being from the boiler fronts over the tops of the shells to the smoke connection on top of the settings at the rear. The furnaces are hand fired, being fitted with McClave shaking grates for the burning of fine grades of anthracite coal, and the fronts of the setting are fitted with water arches over the fire doors through which the feed water is passed for preheating before entering the boiler.

The products of combustion are removed by a 150-ft. circular brick stack just outside the rear of the building and connected to the boiler flues by a 48x72-in. breeching at the level of the top of the settings. The stack has a 66-in. clear inside diameter to the top, the lower 22-ft. of the stack being square in section, while the upper portion is circular and is capped by a cast-iron cap cemented in position. The stack was erected by M. W. Kellogg & Co., New York. The boiler branches from the breeching are $3\frac{1}{2}$ ft. square over each shell, changing thence to 2 by 8 ft. at the front. The flues are fire-brick throughout, supported on cast-iron T-bars and specially designed to prevent cracking. The draft from the stack is controlled by a Locke damper regulator mounted at the front of the boilers and operating the dampers through a shaft extended back to the flue connections at the rear; this shaft is mounted on ball bearings and operates a working damper in the flue connection to each boiler. There is also a large damper in the main flue connection to the stack arranged for hand control from the rear of the settings.

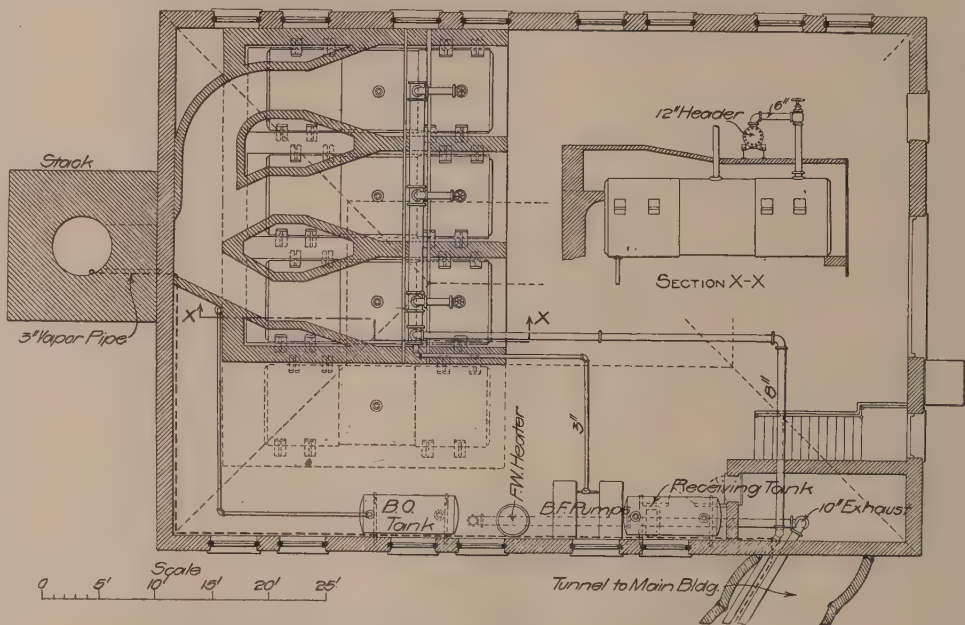
The boilers are fed by two Worthington duplex pumps in duplicate, each having $7\frac{1}{2}$ and $4\frac{1}{2}$ -in. cylinders with 10-in. stroke. They have suction from a 42x96-in. cylindrical steel receiving tank mounted on the sidewall about 6 ft. above them to which condensation, returned from the heating system of the building, is delivered and through which the make-up water is added from the city mains when required. These pumps are not fitted with a governor but are placed under the control of a fireman, there being necessarily one man always on duty in the boiler room. The pumps deliver to the boilers through a 3-in. feed main which leads first to the feed water heater with by-pass around the latter, and thence along the boiler fronts, where $2\frac{1}{2}$ -in. branches are led through controlling valves to the water

arches above the furnaces; from these arches the feed is delivered to the boilers through perforated pipes extending through the shells longitudinally just above the tubes.

The feed heater is a 32-in. by 10-ft. Berryman closed heater with $1\frac{1}{4}$ -in. brass tubing, presenting a tube heating surface of 150 sq. ft. The shell has 10-in. connections at the bottom and top to which the exhaust main that is carried over from the power plant in the main building basement is connected; this exhaust main bypasses the heater and is carried up to an exhaust head above the roof line, so that exhaust steam may be passed through the heater or by-passed directly to the exhaust head as desired. The back-pressure valve, usually provided between the feed heater and the exhaust head, is in this plant located in the basement of the main building. In the winter there is insufficient exhaust from the steam-using machinery to provide for adequate heating; at such times no steam escapes to the feed water heater and it is cut out of service, this

heavy wrought-iron with flanged connections, that for high pressure being designed for 200 lb. The high pressure piping is covered throughout with Keasbey & Mattison 85 per cent. magnesia covering while the low pressure piping is covered with H. W. Johns-Manville felt, all $1\frac{1}{2}$ -in. thick with a canvas jacketing. The arrangement of connections to the tunnel pipe line is such that expansion is easily provided for, there being right angle turns at both top and bottom of the shaft at the boiler house ends, while a 30-deg. bend of the tunnel near the main building introduces an additional bend which permits contraction and expansion.

Spacious quarters are provided for the machinery in the sub-basement of the main building as shown in the plan. The ventilation ducts are in all cases carried on the ceiling and practically all of piping is also on the ceiling, there being no trenches or pits except a 13x16-ft. pit in the westerly portion of the sub-basement, depressed 3 ft. below normal floor level to accommodate the



Plan of Detached Boiler House of the Newark City Hall.

being practicable as the condensation returned from the heating system is delivered to the feed pumps at a high temperature and furthermore the feed is delivered to the boilers through the furnace water arches for additional heating. This back-pressure valve is a 10-in. Jenkins excelsior straightway valve.

The blow-off system consists of a 3-in. blow-off main at the rear of the settings with $2\frac{1}{2}$ -in. branches to each shell, which main delivers into a 42x96-in. cylindrical steel tank at the side of the boiler room. This tank is above the sewer level, so that free drainage to the sewer is permitted, but the discharge connection is so made that the tank is maintained about half filled with water for the purpose of cooling the discharge received from the boilers. A 4-in. vapor pipe is carried up from the shell of this tank to the roof for removal of steam escaping from the hot discharge.

Steam Piping.—The steam piping of the plant is simply arranged, consisting of a 12-in. boiler room header over the boiler setting, from which a 3-in. branch extends to supply the feed pumps in the boiler house and an 8-in. line is carried through the tunnel to the power plant in the basement of the main building. From the steam-using machinery in the power plant a 10-in. exhaust line is extended through the tunnel back to the boiler house, where it connects with the feed-water heater and atmospheric riser to the roof exhaust head. The steam piping is all extra

condensation receiving tank of the heating system, the pump governor, return pumps and a cess-pool.

The steam-using equipment in this section consists at present of the elevator pumps, two house pumps, two condensation return pumps, the Corliss engine for operating the ventilating fans, and the radiation of the heating system. To supply this equipment with steam, the 8-in. high pressure line carried over from the boiler house extends to the central portion of the machinery section, where, near the Corliss engine, it ends in a cross with a 5-in. connection to supply the elevator pumps, an 8-in. connection to the heating system, and an 8-in. branch blanked for future extension to the engine room when required. From this last extension a 6-in. branch is taken to supply the Corliss engine and a 3-in. branch to supply the condensation return pumps, while from the branch to the elevator pumps, a $1\frac{1}{4}$ -in. line is extended to the hot water heating tank in the opposite end of the basement. The live steam connection to the heating system is made through a 6x8-in. Foster pressure-reducing valve with 4-in. by-pass, which connects directly to the 16-in. low-pressure header of the heating system.

The exhaust steam system which forms the basis of the steam heating system, is similarly planned to facilitate the addition of electrical generating machinery without change in the present installation. It consists of a 16-in. exhaust header which extends in the direction of the future en-

gine room to a blanked flange, into which header all of the present steam-using machinery exhausts. The connections consists of an 8-in. line from the Corliss engine and the elevator pumps and a 3-in. line from the house pumps and condensation return pumps in the pit. The exhaust steam passes from the header to the heating supply main through a 16-in. Peerless grease extractor, furnished by Hussey, McCann & Co., New York, for the removal of lubricating oil. The extractor is mounted on the ceiling for convenience of connection to the header and supported by a substantial brick pier, the dirty drips from the receiver being discharged through a Heinz steam trap to the adjoining cesspool. Beyond the grease extractor, connection is made to the 10-in. line that extends through the tunnel to the boiler house for heating feed water when excess exhaust steam is available for that purpose. Between the latter connection and that for live steam supplementary supply, a gate valve is inserted to permit separation of the header into two divisions, permitting the heating system to be supplied solely by live steam, if desired, when the exhaust steam will be discharged from the header through the 10-in. line to the boiler house roof exhaust head.

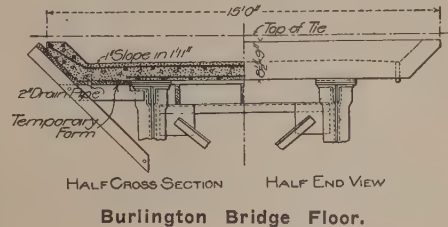
Elevators.—The elevator system is hydraulically operated, the pressure for which is supplied by two 14 and 20x10x15-in. Worthington compound duplex pumps located with the necessary piping and tanks in the space within the dome foundations. Each pump is supplied with steam through a 2½-in. connection, with a Ford governor for control by the hydraulic pressure. The pumps draw through 8-in. suction connections from a large open discharge tank and deliver through 8-in. connection to a cylindrical steel pressure tank, from which the hydraulic pressure is supplied to the elevator control valves. The pressure tank is a 30-ft. steel tank 6 ft. in diameter, designed to withstand the operating pressure of 150 lb., and is maintained half filled with air for air chamber equalization of fluctuations of load. The discharge tank is an open steel tank 6x32 ft. in size and 6 ft. deep, into which the various discharge lines from the elevator control valves discharge. There are five passenger elevators in the main building and one as hoist in the boiler houses, all of the plunger type and installed by the Otis Elevator Co., New York. The five passenger elevators are arranged to run from the basement to the fourth floor, a total rise of approximately 70 ft. The four machines under the dome are designed to carry maximum loads of 3,000 lb. at a speed of travel of 300 ft. per min., while the fifth elevator, in the northwest corner of the court, is designed to carry 1,500 lb., at the same speed. The four larger machines have 7½-in. plungers, while the smaller elevator has a 5½-in. plunger. The ash hoist has a rise of about 10 ft. and a capacity of 1,500 lb.

Electrical Equipment.—The electrical installation is unusually extensive, decorative lighting and special illuminating features forming an important part of the building's equipment. A liberal use is made of studded ceiling and cove lighting, avoiding in general the use of large and complicated chandelier designs. The wiring system has been designed for abundant lighting of all rooms and departments of the building, there being a connected load of nearly 8,000 incandescent lamps, the greater part of which are, however, 8 c.-p. lamps in the decorative ceiling lighting scheme. But two motors are used in the building, driving ventilating fans on the roof.

The scheme of illumination is a practically general application of studded ceiling lighting by rows of 8 c. p. lamps. The corridors encircling the open interior court have rows of ceiling lamps on 12-in centers lining the cornices on the sides opposite from the court. All of the large offices

and assembly rooms and many of the smaller offices are similarly illuminated, the lamps being very generally in rows bordering the cornices and distributed on 24-in. centers. In the council chamber and dome over the central portion of the corridor, special lighting schemes are attempted in which studded lighting is utilized with striking effect. The location and distribution of lamps are in all cases carefully proportioned for effective general illumination, the intensity of which may be varied by operating different combinations of lamp groups. This method of illumination rendered the wiring scheme very extensive and necessitated a very large number of outlets, the system providing in all 7,467 outlets for lamp connections. Of these over 1,400 are on the first floor, over 2,000 on the second floor, 1,460 on the third floor, 1,430 on the fourth floor, while the remainder are in the sub-basement and boiler house. The current supply of this lighting equipment is distributed by forty main feeders which vary in size from No. 1 to No. 0000 and extend from the main switchboard in the engine room to local distributing panel boards in various parts of the building.

The wiring of the building is divided in gen-



Burlington Bridge Floor.

eral into four divisions, embracing the four sides of the building encircling the court, which greatly facilitated the running of the main feeders from the switchboard to central distributing boards on every floor. There is thus a panel distributing board on each floor near the middle of the corridor on each side facing the court, making six rows of boards on each of the four sides, all served by a single group of riser lines, or 24 boards in all, which together with two additional boards for special service, make 26 panel boards supplied by independent feeders, each under separate fuse and circuit-breaker control at the main switchboard. The feeders are extended to the groups of riser lines of panel boxes on the upper floors through lines of large conduits under the sub-basement floor which spread out into large convenient pull boxes at the base of each riser. These boxes are of heavy cast-iron with bottoms 1 ft. above the sub-basement floor and have heavy doors to enclose connections. A separate conduit is provided for each feeder, so that both the initial installation and subsequent access to any feeder for examination or repairs is greatly facilitated. All of the wiring for both feeder and distribution circuits is installed in concealed loricated conduit run on the loop system throughout. The main feeder cables are lead-sheathed from the switchboard to the pull box connections, beyond which standard rubber-covered wire is used throughout.

The switchboard is a six panel board of white marble, 25 ft. in length, mounted on an angle iron frame. It is at present enclosed in a glass partition for protection from dust and dirt in case the engine room is used for storage purposes. The board has eleven 400-ampere knife switches and circuit breakers, ten of 200 ampere capacity, two of 600 ampere capacity and two of 3,000 ampere capacity; a 5,000-ampere General Electric wattmeter, a 150-volt Thomson inclined-coil voltmeter and a ground detector switch, no apparatus having as yet been installed for use in connection with generating appar-

atus. The present current supply is at 120 volts alternating current, on the two-wire system, from the local lighting company.

The new City Hall was designed and its equipment selected by and installed under the supervision of Messrs. John H. and Wilson C. Ely, architects, Newark, N. J., and Mowbray & Uffinger, New York. The details of the mechanical equipment were designed by Mr. James H. Seymour, Jr., Newark.

(To be Continued.)

A Solid Floor for Plate-Girder Spans.

Some features of plate girder design have recently been revised for standard construction on the Chicago, Burlington & Quincy Ry., where no bridge is considered up-to-date without a ballasted floor, and both deck and through plate girder spans are designed to receive reinforced concrete floors, although wooden floors may be used with them if desired. In a 75-ft. through span there are two girders 15 ft. 6 in. apart on centres and 8 ft. 4¼ in. deep, back to back of flange angles. Two lines of horizontal angles 18 in. apart in the clear are field riveted to the inner faces of the webs, with vertical legs inside, to form connections for the concrete floor construction, the top of the lower 4 x 4 ¾-in. angle being flush with the top flanges of the stringers. With this construction the height from the top of the tie to the masonry is 3 ft. 10¼ in., and with the open floor it is 3 ft. 2 in. From the top of tie to clearance line is 3 ft. 3¼ in. and with the open floor it is 2 ft. 7 in.

Four deck spans have floors 15 ft. wide over all, with concrete slabs 8½ in. thick reinforced with transverse and longitudinal bars in the upper and lower surfaces. The outer edges of the slab are inclined upward at an angle of 30 deg. to make flanges 9 in. deep to retain their ballast. The top lateral system and the top angles of the sway brace frames are lowered clear of the top flange angles of the girders, to permit the forms for the concrete to be set with greater ease and to be supported on the transverse frames and lateral angles. The outstanding flanges of the vertical web stiffener angles in such girders are punched for connecting bolts to the knee-braces of concrete forms. A 75-ft. deck span weighs 95,800 lb. and one girder weighs 17,900 lb. For a 75-ft. through span the corresponding weights are 144,400 lb. and 40,860 lb. A 105-ft. deck span over Pope Creek on the Galesburg division weighs 208,000 lb. Its concrete floor weighs about 1.2 tons per lineal foot and raises the allowed unit stress from 4.86 tons allowed for ordinary floors to 5.5 tons.

All designs are made and the construction supervised by the Engineering Department of the railroad, Mr. W. L. Breckenridge, chief engineer, Mr. C. H. Cartlidge, bridge engineer. The Morava Construction Co., Chicago, was the contractor for the Pope Creek Bridge.

THE FLORIDA EAST COAST CANAL has been cut through from St. Augustine to Miami and work will shortly begin on its extension northward to the St. Johns River, affording a connection with Jacksonville. The construction has been under way for many years, backed mainly by Boston capital. The portion of the canal now completed is 55 ft. wide at the bottom and has from 6½ to 7½ ft. of water. Steamboats will be placed in regular service by the Florida East Coast Line & Transportation Co., which is constructing the canal, and it is expected that the long stretch of attractive land-locked water-way will bring many small yachts and house-boats. In addition it will furnish a useful method of transportation for every one along this noted portion of the Atlantic coast.

The Chateau des Beaux-Arts on Huntington Bay.

In the construction of the Chateau des Beaux-Arts, a large summer resort now being built on the south shore of Huntington Bay, Long Island, concrete has been used almost exclusively, not only as a structural material, but also in forming the exterior and interior architectural ornament for the various buildings. The structures contemplated in the general scheme are: A large 3-story and basement central hotel building, with a 145x51-ft., 60-room wing on each end; a 135x36-ft. casino, with public and private dining rooms, billiard rooms and a roof garden; a garage to accommodate fifty automobiles; bathing pavilions and grounds for polo, tennis, golf and other sports. It is expected that ultimately a number of villas will be built on the rising ground in the rear of the hotel to be rented to summer occupants. The casino is now practically completed and the east wing of the hotel is well under way. These buildings and the garage will be available for the present season. The west hotel wing will be built next year and the central hotel building and other structures as soon as they are needed. The site of the main hotel building is now occupied by a 3-story frame hotel formerly known as Locust Lodge. This will be used as the main building at present and later will be moved to another site where it will serve as an overflow annex.

Where this development is in progress the land overlooking the bay rises sharply from the narrow beach, which is wholly covered at flood tide, to a height of about 20 ft., and then slopes gently back for about half a mile. A sea-wall of plain concrete is being built along the toe of the bluff in front of the chateau. Only about 205 ft. of wall is to be built at present, this portion being immediately in front of the casino. Later it will be extended in both directions to a total length of about 600 ft. The wall proper is 8 ft. high, 7¾ ft. wide at the footings and 2 ft. wide at the top. It is surmounted by an ornamental parapet wall about 2 ft. high, on the top of which will be placed growing plants in wooden boxes. The footings of the wall are about 5 ft. below mean tide and rest on chestnut and oak piles 15 to 30 ft. long, stagger-spaced on about 4-ft. centers, which were driven to refusal in the gravel. The wall is built in 32-ft. alternate sections with a concrete key and keyway at each joint. The part of the wall below flood tide level is built during periods of low tide. The manner of delivering the concrete to the wall will be referred to later.

Above the sea-wall on the edge of the bluff is the casino. This is a reinforced concrete structure about 135x36-ft., having a 1-story and basement central section which becomes at each end two stories and basement, by the addition of small pavilions, shown in the accompanying illustrations. The main floor is at El. 20.6, or about the same as the top of the bluff. In front of the casino, extending its whole length, at El. 20.1, is a concrete terrace 9 ft. wide, from each end of which stairs lead down to a 12-ft. terrace at El. 9.1, about 2 ft. below and just inside the top of the sea-wall parapet. In the rear of the casino is a low terrace garden, under which the basement is extended with a concrete column and slab construction. This portion of the basement, in which are kitchens and serving pantries, is connected with the hotel buildings by a reinforced concrete tunnel, 8½ ft. wide and 10 ft. high. The basement directly under the casino building will be occupied by the cafe, billiard room and private dining rooms. The restaurant and other dining rooms will occupy the main floor, and on the roof of the central part of the building will be an open garden overlooked by

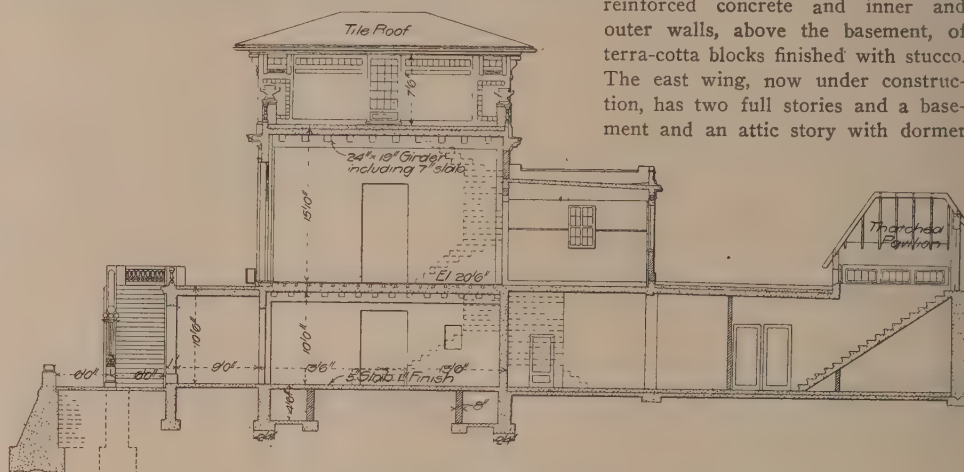
private dining rooms in the two end pavilions.

The basement also extends under the upper terrace about 9 ft. beyond the front wall of the casino along its whole length. In front of the central section of the building this extension forms a long corridor, the floor of which is only 4½ in. above the sea-wall terrace, which is reached from the corridor through arch openings forming an arcade. The 1x4-ft. piers of the arcade are spaced 12½ ft., center to center, and support the front of the upper concrete terrace and its balustrade. They are without vertical reinforcement, but each arch is reinforced with two ½-in. round rods with bent ends and two similar rods are placed over each pier top.

In the casino space has been economized by building the wall and interior columns partly or wholly within the walls. The columns carrying the greatest weight are those on 12½-ft. centers along the front and rear sides of the cafe and restaurant. To these are attached the wall girders and the transverse girders which carry the main and the roof-garden floors. These columns are T-shaped, the stem of the T being

strips lightly tacked to the inside of the forms to form a dovetail attachment for the cement bed moldings. Each dovetail is formed by three strips of wood, the center strip being triangular in section with its edge at the bottom of the dovetail and its greatest width flush with the surface. When the middle strip is taken out the other two can be removed readily without breaking the edges of the concrete dovetail. Between the bracket rods, in the position shown in the picture, were placed short pieces of tin speaking tube just long enough to extend through the corona. Through these tubes will be passed the wires used together with cement mortar in firmly attaching cement dentils. When the attachment is complete the wires will be wholly embedded in cement mortar to conceal them and protect them from corrosion.

The site of the hotel buildings is about 200 ft. in the rear of the casino. The main building will have on each side a wing; the three buildings being connected by a reinforced concrete covered passageway and all facing the bay. Each building will have a framework and floors of reinforced concrete and inner and outer walls, above the basement, of terra-cotta blocks finished with stucco. The east wing, now under construction, has two full stories and a basement and an attic story with dormer



Cross Section of the Casino.

very short and enclosed in the wall. Their sectional dimensions in the basement and main stories are shown on an accompanying drawing. Each column is reinforced with four 1-in. round rods, one in each of the two inside corners, and the other two immediately in front of these near the outer surface. Hoops of ¼-in. round steel wire encircle the rods at 12-in. intervals.

The main floor and roof girders have a clear span of about 25 ft. and are 2 ft. wide and 18 in. deep, including the 7-in. floor or roof slabs, which are carried by the girders without intermediate support. Each girder is reinforced with one 1¼-in. and five 1½-in. rods placed near the lower surface. Each rod is 20 ft. long, including a 4-in. right-angle bend at each end. Three rods are tied into the column at one end of the girder and the other three rods are fixed in the column at the opposite end. The reinforcement near each end is therefore only half as much as that in the central three-quarters where the rods lap over. Each girder is also reinforced with four ¼-in. additional rods disposed in the upper half of the girder, as shown in an accompanying cross-section. These rods, however, serve more as a support for the stirrups and floor slab rods during construction than as reinforcement.

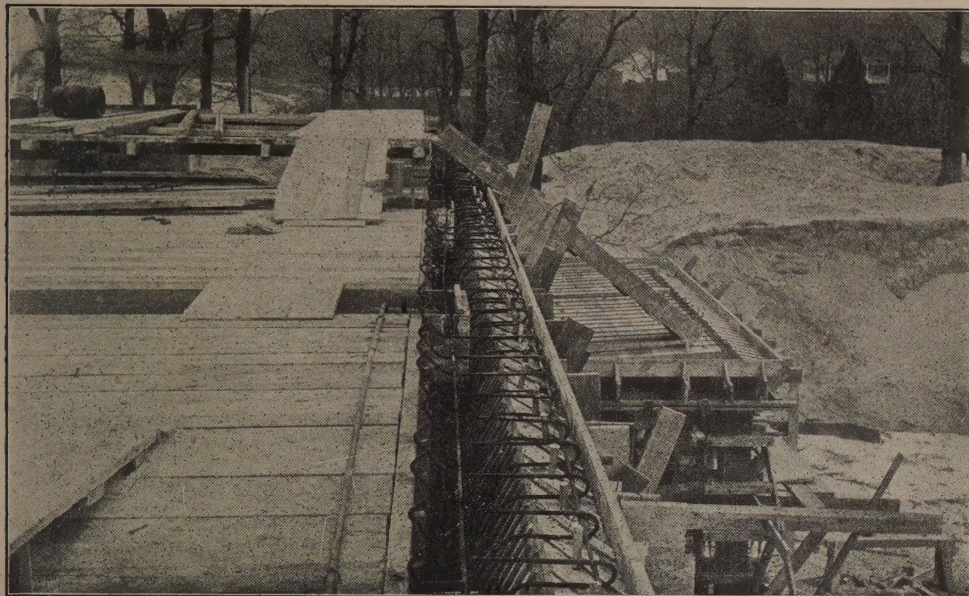
The wall girder below the roof slab forms the basis of an ornamental entablature, the upper part of the girder being built out roughly to form the corona of the cornice. This extension is reinforced with brackets made of ¼-in. rods and placed on 12-in. centers. These brackets and the forms for the girders are shown, ready for the placing of the concrete, in an accompanying picture, in which may also be seen the wooden

windows under the mansard roof. It is 145x50 ft. and contains about sixty guest rooms. In each of these stories there is a longitudinal central corridor 6 ft. 4 in. wide along each side of which are arranged the bathrooms and closets with their accompanying chambers, as shown in a partial floor plan, which also indicates the general spacing of the columns.

In the upper stories practically all the columns are enclosed with the walls, their sections being rectangular, square, L, or T-shaped or cruciform, depending on the walls intersecting at a particular column. All the basement interior columns are octagonal and each is reinforced with four ½-in. rods spirally wound with 3/16-in. wire on about a 4-in. pitch. Above the main floor the outer lines of interior columns become cruciform and those along the corridors become square. The latter are in the pipe ducts or closets and do not form 'unsightly corners' in the rooms. Above the basement, hoops of ¼-in. steel on 12-in. centers are used instead of the spiral winding. The arrangement of the reinforcement in making the transition from the octagonal to the cruciform section is shown in an accompanying sketch. In designing the columns 500 lb. was taken as the maximum allowable working stress in the concrete.

The floor slabs are 4 in. thick and are attached to the wall girders and to longitudinal girders extending along the four lines of interior columns. In the chambers the slabs are reinforced by longitudinal and transverse ½-in. rods on 6-in. centers in each direction. The corridor floors are reinforced with ½-in. transverse rods

on 6-in. centers and every third rod extends through to the inside chamber walls to provide reinforcement for the floors of the bathrooms, hallways and closets. The interior floor girders are 5x14 in., not including the floor slab, and each is reinforced near its lower surface between columns with two 1-in. rods. Extending through each column and into the girders near the upper surface of the floor slab are two 1-in. rods about 7½ ft. long. Stirrups of ¼-in. round steel are used to tie the upper and lower rods together.



Cornice Brackets in Wall Girder of the Casino.

The 8x21-in. wall girders at the sides and ends of the building form the basis for applied cement ornament of the general form shown in an accompanying cross-section. These girders are not designed primarily to carry the curtain walls, as the latter are built in solidly and their weight is transmitted to the concrete basement and foundation wall, but they act as floor girders, window lintels and building ties combined.

The garage as completed will be a 274x47-ft., 2-story reinforced concrete structure, but only one story is to be erected at present. Except for some small rooms at each end the entire floor area will be available for the storage of automobiles. There are two lines of 12x12-in. interior wall columns, placed 10½ ft. from the nearest sidewall and spaced on 17-ft. centers longitudinally. The 6-in. second floor slab is carried by transverse girders 12 in. wide and 24 in. deep, not including the floor slab. In designing this floor system it was assumed that the attachments at the ends of these girders and at their intersections with the interior columns were fixed, thus making the resisting moment of the wall and interior columns a factor in the support of the floor load. The arrangement of the reinforcing rods in these girders is shown in an accompanying sketch.

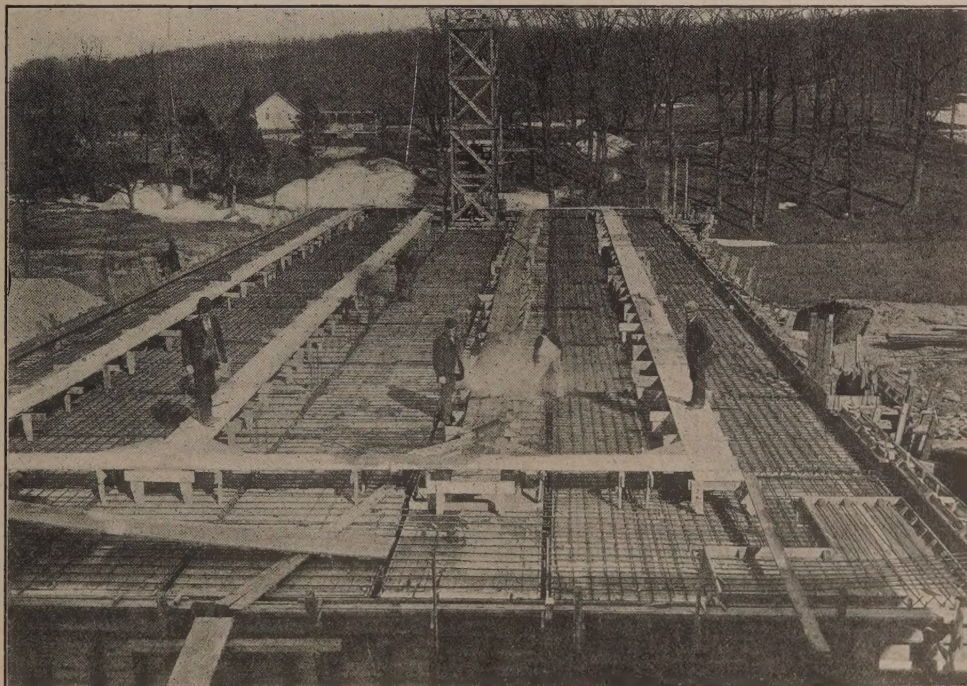
The concrete used in the structural work in all the buildings is made of Atlas Portland cement and unscreened beach gravel and is equivalent to about a 1:2:4 mixture. The cement is delivered in lighters at a dock about a mile and a half from the work and is hauled the remaining distance in wagons. The gravel is piled up on the beach in front of the casino with two-horse drag scrapers, when the tide is low, and is shoveled into two 1-yd. side-dump skip cars, which are hauled to the top of the bank on a double-track trestle incline by a Lidgerwood double-drum hoisting engine. At the top of the incline the cars are about 15 ft. above the ground.

They are dumped by an automatic device, which trips the side-door catches, allowing the gravel to fall to a pile from which the supply for the casino is taken in wheelbarrows. The supply for the other buildings is dumped from the cars into chutes through which it flows into dump carts. This hoisting engine is also used on the pile driver for the sea-wall, a supply of gravel being accumulated in advance sufficient to serve the work while the engine is not available for hoisting. The costs of material and handling are thus reduced to a minimum.

engine through a friction clutch and drum. A similar equipment is used at the east hotel wing. The concrete for the sea wall is mixed in the Ransome mixer at the casino and delivered to wheelbarrows on the main floor. It is then wheeled out on the upper terrace and dumped through chutes into the wall forms. Beyond the ends of the casino a trestleway has been built at the same level as the upper terrace, on which the wheelbarrows are run out.

In erecting the two buildings now under construction the column forms in each story have been set up and filled before the girder and floor centering for the floor above was put in position. This has been done so that the girder reinforcing rods at the top of the columns would not impede the ready flow of concrete into the form. In the hotel the columns in the three upper stories have the same lengths from the floor surface to the bottom of the girders above. This makes the same column forms available for each floor. The column forms end at the bottom of the girders and in framing the latter special pieces are cut and used as needed. All the forms are built on the work in a fully equipped shop.

The reinforcement of the chamber floor slabs in the hotel wing consists of a double series of rods which were formed into mats of the proper size on a square wooden frame, the side pieces of which were notched to insure the proper spacing of the rods and facilitate the work. The intersections on all four sides were securely tied with wire and the mats put aside to be hoisted to the floor and placed where needed. The first floor of the hotel wing, just before the placing of concrete was begun, is shown in an accompanying illustration which also indicates the arrangement of the wheelbarrow runways and the position of the elevator.



First Floor of Hotel Ready for Concrete.

The concrete for the casino is prepared in a Ransome mixer placed in the basement near the center of the south side of the building with its hopper at the level of the main floor. It is driven by a New York Safety Steam Power Co. engine, supplied with steam by a vertical boiler some distance from the building. The mixer delivers into a dumping bucket elevator in the stair shaft which in turn delivers on each floor to a hopper from which wheelbarrows may be filled. The elevator is operated by the mixer

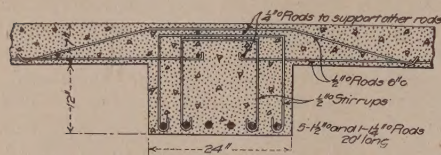
The cement ornament used on these buildings is formed in two ways. Balusters, hand-rails, columns, door-sills, dentils and similar pieces are cast in wooden molds made in the carpenter shop on the grounds. For this work a 1:3 mixture of Atlas Portland cement and beach sand is used, mixed about as dry as molding sand. It has been found that better results are secured if the mixture is allowed to take a slight initial set and is then retempered before being placed in the molds. This seems to prevent the

appearance of fine hair cracks and apparently in no way lessens the permanency of the work. The mixture is thoroughly rammed into the mold with ordinary wedge-shaped wooden molder's tampers. The casting is taken from the mold as soon as practicable and any broken corners or other imperfections are repaired with fresh mortar, carefully tamped into place and formed. In making the molds the carpenters work from full-size drawings provided by the architects.

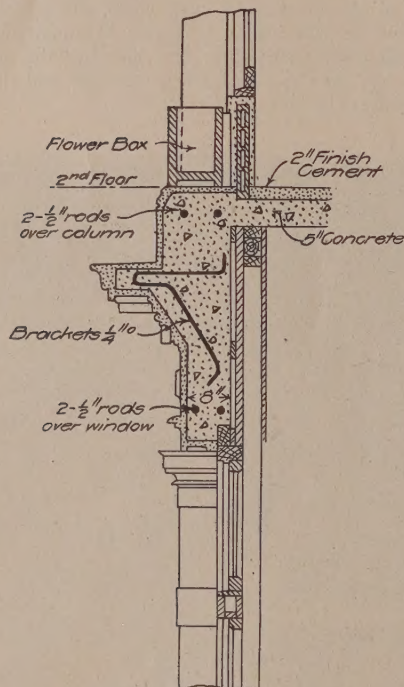
Cornice and interior moldings of cement are formed with a screed in a manner similar to that generally used in forming plaster moldings. The rough concrete surface is first prepared by washing it thoroughly and dusting it while wet with a 1:1 mixture of very fine sand and cement, which is then rubbed in with an ordinary calamine brush. A thin coat of a 1:3 mortar, mixed rather dry, is then worked on with a trowel. The ornament is then built up in $\frac{1}{2}$ -in. layers, a metal-faced screed, running on wooden guide strips being used to form the desired molding. Each layer of mortar is allowed to set 3 or 4 hr. before another is applied.

False floor girders, which have been liberally used to divide the restaurant and cafe ceiling

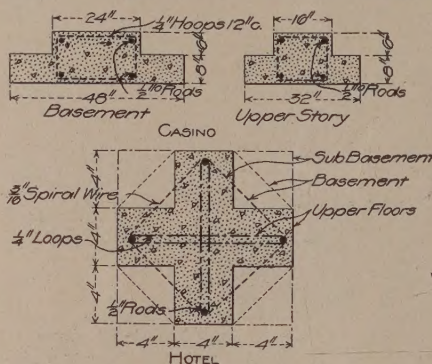
a draftsman in the office of the architects, and besides, secured for the owners a superintendent whose ability he could guarantee, who has had charge of all the execution. By this means large economies were secured in the design, jointly and simultaneously developed by the engineer and architect, along economic and artistic lines, respectively. In the same manner, economies in construction have been practiced by the engineer and owners working together so that the actual unit costs are said to be phenomenally low. If it had not been for the rigor of the past winter and the exposed site of the work, the progress would have been even better and the costs still lower. It may be noted that the methods herein followed are one solution of the difficulty usually encountered when reinforced concrete contractors are allowed to submit bids on their own designs. Even had the owners decided to erect the work by contract the same method of design would have been advantageous.



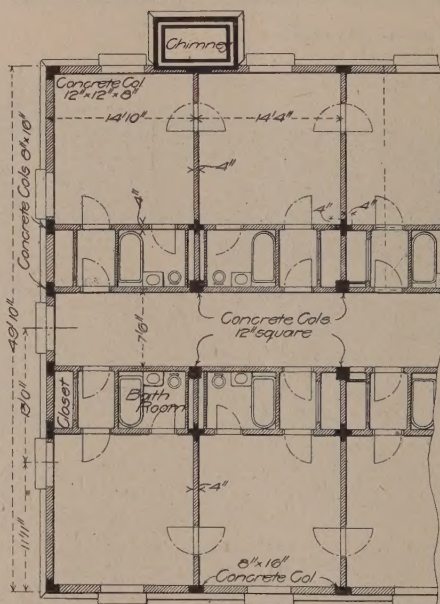
Section at Center of Casino Girder.



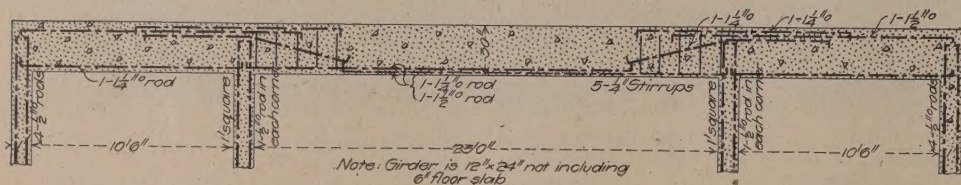
Wall Girder and Cornice of Casino.



Sections of Columns.



Part of Upper Floor of Hotel.



Reinforcement of Columns and Girders of Garage.

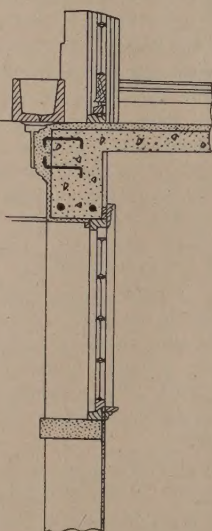
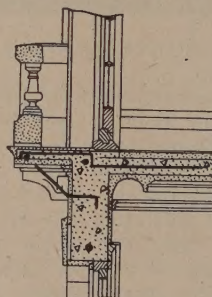
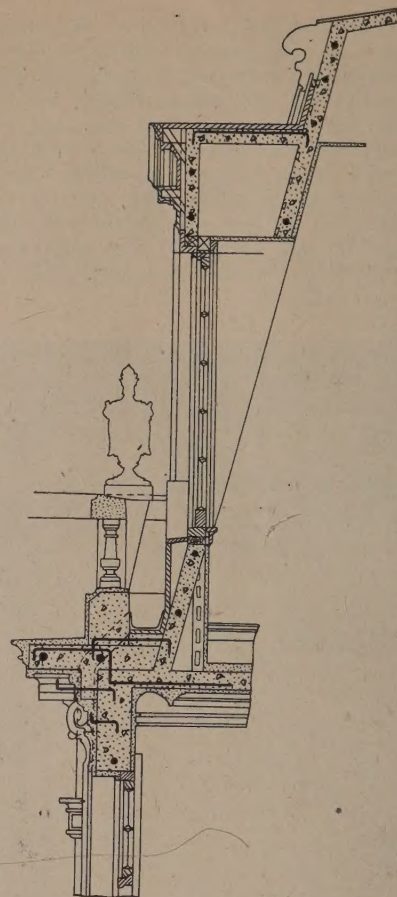
ings into panels, are formed of cement mortar laid on expanded metal strips bent to shape over strap-iron brackets bolted to the ceiling with small wagon bolts, the heads of which are embedded in the ceiling concrete.

A rather interesting method was followed in the design and execution of this job in that the consulting engineer did most of his work through

Messrs. Bustanoby Bros., proprietors of the Cafe des Beaux-Arts, New York City, are the builders and owners of the structures described. Messrs. Delano & Aldrich and Maurice Prevot are the architects, and Mr. E. P. Goodrich is the consulting engineer for the design and execution of the reinforced concrete work. All the details of the construction work have been under the

supervision of Mr. Edward Mahl, superintendent.

AN IMPORTANT CORRECTION should be made in the discussion of the Quebec bridge printed last week. The center post carries less than one-fourth of the entire shear of the cantilever and anchor arms, according to Mr. Theodore Cooper, instead of all of it, as stated.



Section of Hotel Wall.

Highway Work in Allegheny County, Pa.

Allegheny County, Pa., has now under construction 60 miles of macadam road, which when completed will bring the total of the county's hard roads up to 275 miles. The road work of the county since 1897 has been under the so-called Flinn Act, passed by the Pennsylvania legislature in 1895, which authorizes any county to take over from the townships such roads as it intends to improve, these roads then becoming county roads to be maintained thereafter without expense to the township.

The county has an area of 750 sq. miles of rough picturesque country, cut by deep valleys carrying streams to the three large rivers, the Allegheny, the Monongahela and the Ohio, which meet at Pittsburgh, the geographical, as well as commercial center of the county. The topography has naturally made road construction quite costly, and at the same time has intensified the demand for road improvement. Heavy landslides are a common occurrence, and protection from streams has proved a costly item because of the great number of runs, most of which are torrents in time of high water.

The Road Department was organized in 1897 under the Act above referred to, and since that

8 in. deep, not exceeding 4 in. in width at the top and from 6 to 16 in. long. They are laid by hand with their broadest edges down, and longest side across the road. Not less than 10 per cent. of these stones may be under 7 in. in depth. The stones are laid to break joints, and are bound in place by inserting and driving down wherever possible stones of proper size and shape to wedge in solidly. All projecting points of the top surface are broken off with a hammer and driven into the spaces not already filled by the process of wedging. Wedging stones are driven until the foundation is to grade and 8 in. thick. The foundation is then rolled with a roller weighing not less than 10 tons, until the whole mass is thoroughly bedded into the earth subgrade, and the top is 4 in. below the finished grade at all points.

When the sub-grade is on shale instead of the telford foundation just described, a layer with a finished depth of 6 to 8 in. made with stone that will pass through a $3\frac{1}{2}$ -in. ring, and will not pass through a $2\frac{1}{2}$ -in. ring, is used. This layer is likewise compacted with a 10-ton or heavier roller. The stone used is that found convenient to the work, generally limestone or Ligonier stone.

The surfacing consists of two layers of stone, with sometimes a finishing coat of crusher dust.

ers are owned by the department and used constantly in maintenance work.

The Road Department is under the direction of Mr. George T. Barnsley, chief road engineer of Allegheny County.

Letters to the Editor.

POCKET BAROMETER RECORDS.

SIR: You may be interested in the sheets inclosed, being the record of a pocket aneroid barometer. I have had this a little less than a year, and have traveled with it many thousands of miles, and across the United States, both east and west and north and south, and over the Rockies many times, and to the tops of some of our highest peaks. The inclosed sheets represent the record over a portion of the Canadian Pacific, of the Oregon Short Line and the Union Pacific railroads from Calgary in Alberta, via Spokane to Butte, Granger and Denver.

I find the instrument reliable within its limit of accuracy. The elevations on the present sheets should be increased by about 1,000 ft. You will see that they show a fairly accurate profile of the roads traversed. The horizontal distance is a function of the speed and consequently the profile is not to the same horizontal scale unless the speed is uniform. It serves, however, as an interesting record for reconnaissance.

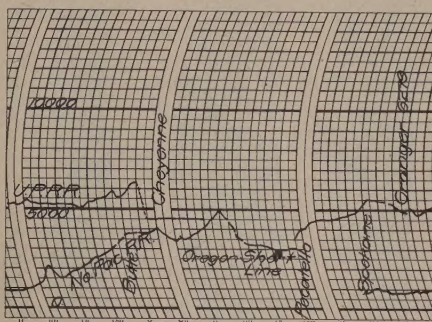
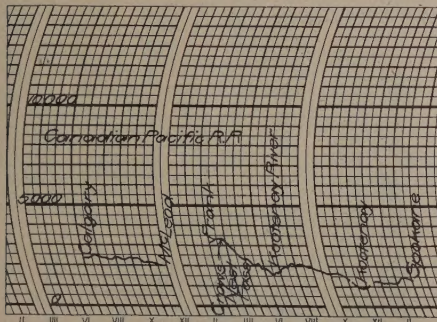
The instrument consists of a small aneroid barometer with a pen something on the plan of the Richard recording instruments, the whole case being about $3\frac{1}{2} \times 4\frac{1}{2} \times 1\frac{1}{4}$ in. thick. The thing which makes it a success in railroad riding, walking and horseback riding, is the idea conceived by the maker of keeping the pen from the paper except at intervals of about two minutes. It then touches the paper for a short instant and is withdrawn, but without giving time for a long line.

I have carried the instrument on foot, on horseback, in my pocket and in all ways, without trouble in the record. Once in climbing a mountain, I slipped, fell down and rolled over, but without any effect upon the record. Should a jump take place at just the instant when the pen touches the paper then, of course, there would be a long line at right angles to the trace. When the descent or ascent is fast, the dots may not form a connecting line, as is shown in the passing of the hill near Cheyenne. This particular record included the crossing of the Rockies four different times. First at the Crow's Nest Pass on the Canadian Pacific, second, on the Northern Pacific some distance west of Butte, the third, on the Oregon Short Line east of Butte, and the fourth on the Union Pacific at Sherman Hill west of Cheyenne.

Yours very truly,
Fort Collins, Colo. L. G. CARPENTER.

CONCRETE SLAB FORMULAS.

SIR: In your issue of Aug. 3, page 131, you give prominence to a solution of the flat slab in reinforced concrete given by Prof. W. C. Unwin. It seems to me that the solution is one open to question. Prof. Unwin starts with the assertion that a flat square slab supported on all four sides fractures along a diagonal. Assuming that the bending moment is greatest along the diagonal of a rectangular slab a formula is derived for the magnitude of this bending moment, which is naturally a mathematical certainty, just as the bending moment along the diameter of a circular plate is a mathematical certainty. But the variation of intensity of this moment along the diagonal is entirely ignored, or rather the intensity is taken to be constant. There is just as much error in taking the intensity of this moment as uniform along the diagonal of a rectangle as there is in taking the intensity of the



Cards from Recording Pocket Aneroid Barometer.

date has improved 215 miles of road. In addition to maintaining these roads it also maintains 24 miles of plank roads, which were purchased from corporations that had operated them on a toll basis. These will be maintained as they are until they are changed to macadamized roads. The earth roads still remain under the township authorities, the Road Department concerning itself entirely with hard roads. The total length of roads of all descriptions in the county is 1,766 miles.

The present development contemplates the expenditure of about \$1,000,000 per year. The main roads radiating from Pittsburgh are first improved, and when this work is completed connecting lines will be taken up, though where the latter are very important they are taken up at the same time as the other improvement. A county road tax and bond issue furnish the funds for the work.

The improved roads are built with a telford foundation and have a width of stone of 16 ft., and a width between slope lines of bank of 24 ft. The width of stone, 16 ft., allows of the passage of two vehicles abreast without crowding either one off the hard surface.

In improving an old road grades are revised, cutting the sharp hills and filling deep hollows. The sub-grade is rolled with a steam roller weighing not less than 10 tons, and all resulting depressions are filled, and the surface again rolled till it is even and compact. Shoulders are left on each side of the sub-grade and ample provision made for drainage through them. Where the existing soil is of such character that it must be removed, the surface is brought to the proper level with good material. Upon the sub-grade is laid a telford foundation of stones

The first surfacing layer is 2 in. thick when consolidated and is made of stones that will pass a $2\frac{1}{2}$ -in. ring, and not pass a 2-in. ring. After this has been rolled solid a second layer with a finished thickness of 2 in. is added. It consists of broken stone which will pass a $1\frac{1}{2}$ -in. ring, but will not pass a $3\frac{1}{4}$ -in. ring, to which may be added a proportionate amount of screenings, free from dust, that will pass a $3\frac{1}{4}$ -in. ring, and not a $\frac{1}{4}$ -in. ring. This last course is thoroughly rolled until the surface is even and at the finished grade. When a binder course of crusher dust is used, it is thoroughly sprinkled and rolled until the mud flushes to the surface, and until the passage of the roller causes no wave in the surface. The surface of the berms between the broken stone and the gutters is finished with clay or good earth and then rolled.

In many places it is necessary to pave the gutters or open ditches, on either side of the road, and for this work a foundation of 3 in. of rammed gravel is used. Upon the gravel is placed a layer of bedding sand or gravel of sufficient depth to bring the gutter stones which will be rammed in to it to the proper grade. The paving stones are of roughly squared rubble, at least 8 in. in depth, set on edge, and the interstices between them are filled with sand.

At the same time the road is improved, fences on embankments, and watering troughs are constructed. The latter are placed at all springs and water courses.

The maintenance work on roads already improved is carried out systematically, the work being blocked out at the beginning of each year. The broken stone for resurfacing is bought by contract and hauled by contractors to the point of application on a tonnage basis. Six 10-ton roll-

bending moment along the diameter of a flat circular plate as uniform. It may be quite true that a flat slab, either square or rectangular, supported on four sides, will break on a diagonal line. This is proof of one thing, namely, that the greatest intensity of bending moment is at the center of the slab; for, as both diagonals are identically conditioned, either may be the one to fail, and their only common point is the center of the slab. It is not conceivable that the same intensity of bending moment extends clear to the corner of the slab. A crack once started in a diagonal direction would naturally extend into the corner and even over the support, merely on account of the brittleness of the material. This would be no evidence of a constant intensity of bending moment along the fracture. A crack once started in a brittle substance can be extended without the exertion of as much force as is required to start it.

On the same page of your issue the report quoted refers to flat plate theories as being applicable to reinforced concrete. These flat plate theories are worked out for steel plates, where the strength in both tension and compression is the same in all directions, and the extreme fibre stress at both top and bottom of the plate is found to be the same in all directions at the center. Furthermore, in Grashof's formula the true extreme fibre stress is not given, as in the case of beams, but it is throttled by a coefficient (Poisson's ratio). How can a fictitious extreme fibre stress in all directions be converted into actual stress in steel reinforcing rods in two directions? Advocates of Grashof's formula do not seem to have answered this question. They further do not make it clear why it should be necessary to pass through the labyrinth of the flat plate theory and through the loop of Poisson's ratio (and out again) in order to solve a flat plate in reinforced concrete, a material not at all contemplated in Grashof's formula.

Yours very truly,
EDWARD GODFREY.
Monongahela Bank Building, Pittsburg.

COMPARISON OF VARIOUS PILES.

SIR: In designing the foundations of a building, the first and most important point to ascertain is the condition of the ground on the proposed site. It is not only necessary to learn the nature of the ground on the surface but the nature of the underlying strata must be determined. It often happens that while the upper ground may be firm and compact enough in itself to carry the required loads, yet the underlying strata are of such a nature, mud, quicksand, etc., that the application of any load would cause the upper stratum to settle seriously, thereby causing damage to the building. Or it may be that the upper ground is of no account at all for load carrying purposes, mud, swampy ground, etc., making it necessary to support the loads on some firmer stratum of earth found at some distance below the surface. In any such case, foundations are designed which are intended to transmit the loads of the building to firm and reliable ground, whatever distance that ground may be located below the surface of the earth. Sometimes it is found most expedient to use deep footings and heavy piers, going through the poor ground and resting on the good ground underneath. In other cases, principally from the standpoint of economy, piles, either of wood, iron or concrete, and of various sizes, are used for transmitting the loads through the poor earth to the firmer stratum underneath. These piles depend in a great measure for their support on the surrounding earth, and due to the friction between the sides of the piles and the earth, a great part of the load is taken up by the surrounding ground before the point is reached. It will be seen therefore that in using piles, a cer-

tain amount of dependence must be placed on the upper ground, inasmuch as it carries a certain portion of the load, the amount depending on the firmness of the ground.

Were it certain that the upper earth would always remain the same, the risk involved would be small, but there are certain points which make such a possibility uncertain. Very often piles are driven before any excavations are made, so that after the earth has been removed from around the tops of the piles for the capping, a certain amount of carrying capacity has been taken away from them. This, however, does not change the loads the piles have to carry. The lowering of the water level, due to drainage into nearby sewers or others reasons, will allow the tops of wood piles to rot, thereby rendering the proper transmission of the loads imperfect, sometimes causing serious settlement of, and consequent damage to, the building resting on the piles. Again, excavation near the building may destroy the supporting power of the surrounding earth, thereby causing the piles to settle, because part of the supporting surface is rendered useless.

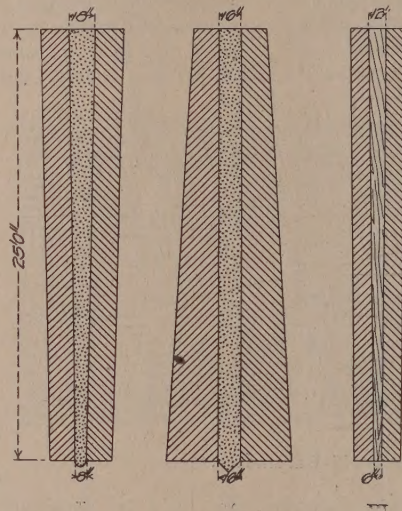


Fig. 1, Load Distribution by Friction.

All of these points must be considered in choosing the kind of foundation to be used for the building. The ideal pile would be one that transmitted the entire load to the firm and reliable ground, wherever that soil might be, placing no dependence on the poor ground through which it passes. There are no piles made which exactly fulfill these conditions, but it should be a matter of interest to everybody to find out which pile most nearly fulfills them.

There are on the market, at present, practically only three styles of piles, the ordinary wooden pile, the tapered concrete pile, either molded before driving or made in place, and the cylindrical concrete pile.

For the purpose of comparing these piles let us assume ground conditions which will bring out the largest number of good points of each system, making the comparison as fair as possible to all concerned. Assume that the ground is of such a firm and compact nature that one square foot of pile surface at the butt of the pile will develop a carrying capacity of 0.35 ton, increasing uniformly to 0.7 ton per square foot of pile surface at the point of the pile. Assume each pile to have been driven 25 ft. into this ground. Also assume the ultimate friction of the concrete and wood against earth to be the same, and neglect the end bearing values of the piles. Then we have the superficial area for one lineal foot of pile at the butt and at the point for each pile to be as follows:

Pile	I.	II.	III.
Butt	4.71	4.2	3.14
Point	2.1	4.2	1.57

Multiplying these areas by the unit loads for the butts and points of the piles and scaling them off as shown in Fig. 1, and connecting the upper points with the lower points, diagrams are obtained which show not only the total loads carried due to superficial friction by the piles but also how the loads are transmitted to the surrounding earth. Fig. 2 shows this more in detail and also gives a table of loads carried by each lineal foot of pile as scaled from the diagram.

The diagram of pile I shows that a slightly greater load is transmitted to the surrounding ground at the butt of the pile than at the point. In other words, the very reason for the use of piles is defeated by placing over half the load on the poor upper earth. The diagram for pile III. shows that the loads are very uniformly distributed to the surrounding ground for the whole length of the pile, which is little better than pile I. The diagram for pile II., however, shows that small reliance has been placed on the carrying capacity of the upper earth, and that by far the greater part of the load is transmitted to the ground around the bottom of the pile. In other words, it shows that as the carrying capacity of the earth increased, the pile placed a

